3.2

FINAL
DECLARATION OF THE RECORD OF DECISION

SITE NAME AND LOCATION

Vancouver Water Station 4
Vancouver, Washington

STATEMENT OF PURPOSE

This decision document presents the selected final remedial action for Vancouver Water Station 4 (WS4) in Vancouver, Washington, which was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for the site.

The lead agency for this decision is the U.S. Environmental Protection Agency (EPA). The Washington State Department of Ecology concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from WS4, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present imminent and substantial danger to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The City of Vancouver's public water supply wells at WS4 are contaminated with tetrachloroethene (PCE). No ongoing source for the PCE in the groundwater has been identified for which cleanup action could be taken. Therefore a remedy that focuses on treatment of the drinking water produced from WS4 has been determined to represent the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner. Even without a source control remedy, the concentration of PCE in groundwater at WS4 is expected to eventually decrease to a level below the maximum contaminant level (MCL).

The selected remedy for cleanup of both the public water supply and groundwater at WS4 is air stripping. Air stripping is a treatment technology in which the water to be treated trickles down through a tower in a packed column that breaks up the flow of water to create as much surface area as possible. Large volumes of air are then forced upward through the water, transferring the volatile contaminants from the surface of the water to the air through the process of evaporation. The air to which the contaminants have been transferred is then treated by forcing it through carbon filters, which adsorb the contaminants. The filters are then regenerated or treated and disposed of as a hazardous waste.

The air stripping system at WS4 has been in operation since January 1992, before the site was listed on the National Priorities List. Use of air stripping has consistently reduced concentrations of PCE in treated water to below the level of detection. This action addresses the principal threat to human health—contamination of drinking water with PCE.

All water pumped from WS4 is treated by air stripping and distributed to customers as drinking water. The rate at which groundwater can be pumped from WS4 is limited by the rate at which the air stripping treatment can treat the water—4,000 gallons per minute (gpm)—which is equivalent to a maximum of approximately 2.75 million gallons per day. The actual production rate is based on demand and is generally considerably less. While the primary purpose of air stripping is cleanup of the water being produced for distribution as drinking water, this action also serves as a pump-and-treat remedy that addresses the contamination of the groundwater at the site. (Source removal is not part of the selected remedy.)

DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision. Additional information can be found in the Administrative Record file for this site.

- ☒ Chemicals of concern (COCs) and their respective concentrations (Table 6-1; Section 7.1.1; 7.1.4)
- ☒ Baseline risk represented by the COCs (Section 7)
- ☒ Cleanup levels established for the COCs and the bases for the levels (Section 8.5)
- ☒ Current and future land and groundwater use assumptions used in the baseline risk assessment and the ROD (Section 7.1.2)
- ☒ Land and groundwater use that will be available at the site as a result of the selected remedy (This is a public water supply wellfield; land and groundwater use are not expected to change as a result of the selected remedy.)
- ☒ Estimated capital and operation and maintenance (O&M) costs (Section 10.7); total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (not included because this information was not available from the City of Vancouver, which is responsible for the operating costs)
- ☒ Decisive factor(s) that led to selecting the remedy (Section 8.4)

STATUTORY DETERMINATION

The selected remedial action protects human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining on site above health-based levels, Water Station 4 will be subject to a 5-year review.

Chuck Findley

Chuck Clarke, Regional Administrator
for U.S. EPA Region 10

9-1-99
Date

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TABLES

ABBREVIATIONS AND ACRONYMS

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
DNAPL	dense nonaqueous-phase liquid
EPA	U.S. Environmental Protection Agency
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IRIS	Integrated Risk Information System
kg	kilogram
MCL	maximum contaminant level
μg	microgram
mg	milligram
MSL	mean sea level
MTCA	Model Toxics Control Act
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NPL	National Priorities List
NTP	National Toxicology Program
PCE	tetrachloroethene (also known as perchloroethylene)
RAO	remedial action objective
RBSC	risk-based screening concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	Record of Decision
SDWA	Safe Drinking Water Act
SF	slope factor
TCA	1,1,1-trichloroethane
TCE	trichloroethene
UCL95	95 percent upper confidence limit
VOC	volatile organic compound
WDOH	Washington State Department of Health

ABBREVIATIONS AND ACRONYMS (Continued)

WS1	Vancouver Water Station 1
WS4	Vancouver Water Station 4

DECISION SUMMARY

1.0 INTRODUCTION

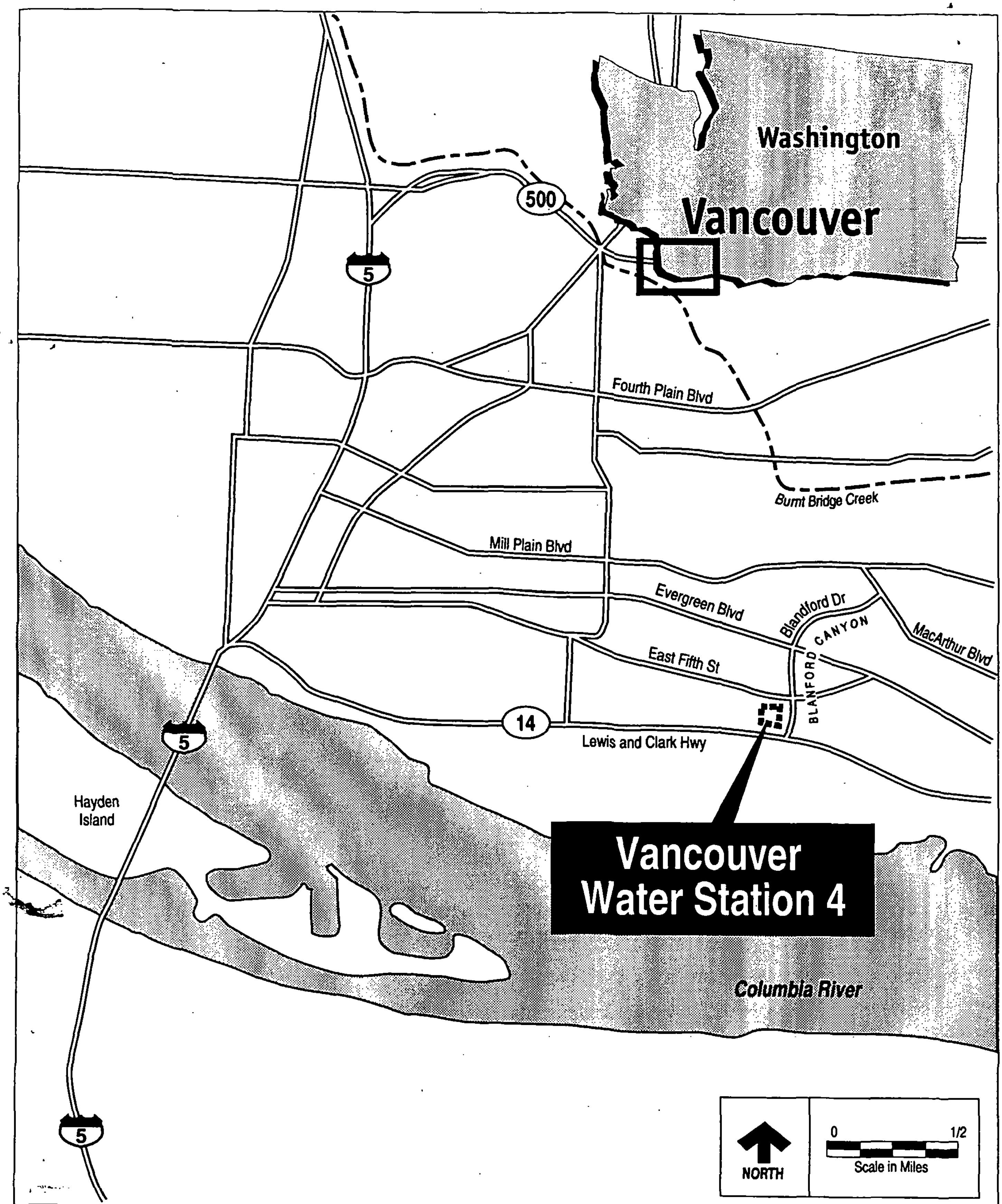
In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the U.S. Environmental Protection Agency (EPA) is selecting under CERCLA the existing air stripping treatment system to address environmental contamination at Vancouver Water Station 4 (WS4) in the city of Vancouver, Washington. The selected treatment system has been constructed and is operational.

EPA is the lead agency for overseeing the implementation of the selected remedy. The selected action has the concurrence of the Washington State Department of Ecology and is responsive to the expressed concerns of the public. The selected action complies with applicable or relevant and appropriate requirements promulgated by EPA, Ecology, and other state agencies.

2.0 SITE NAME, LOCATION, AND DESCRIPTION

WS4, a public water supply station operated by the City of Vancouver, is located approximately ½ mile north of the Columbia River at the intersection of East Fifth Street and Blandford Drive in the city of Vancouver, Washington (Figure 2-1). Vancouver is located in Clark County in the southwestern corner of Washington state, across the Columbia River from the city of Portland, Oregon. The site is located on a river terrace north of Lewis and Clark Highway (SR-14), adjacent to a commercial district and residential areas.

The Superfund site (CERCLIS ID No. WAD 988475158) was listed on the National Priorities List (NPL) in October 1992. The site is defined as the wellfield, which encompasses approximately ½ acre and includes several support buildings, six production wells, two air stripping towers, and one capped well (Figure 2-2). Until the discovery that the groundwater was contaminated with tetrachloroethene (also known as perchloroethylene, or PCE), WS4 provided about 25 percent of the public water supply for the city of Vancouver. Only two of the



EPA REGION 10	**Figure 2-1** **Site Location Map**	54-52-OJ3C Vancouver Water Station 4 RECORD OF DECISION

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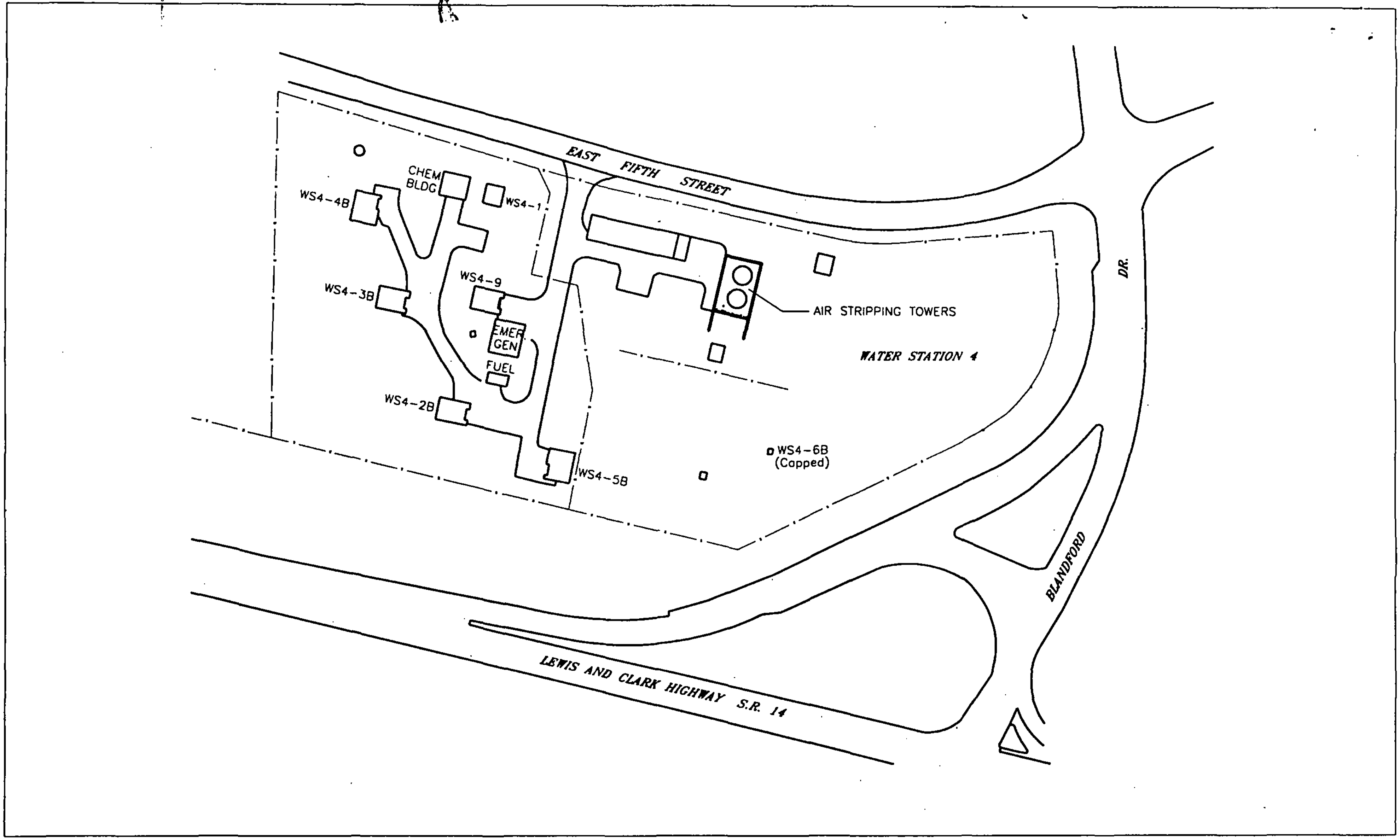

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Figure 2-2
Site Map

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wells—the two with the lowest average concentration of contamination—have been used since 1989. Most drinking water for the city of Vancouver is supplied by other wellfields; WS4 is used primarily to meet peak demands for water, with the largest volumes pumped during the summer.

WS4 pumps water from an alluvial zone in hydraulic communication with the Troutdale Formation, a deep aquifer from which several municipal wellfields and an unknown number of private wells draw water. Investigations into potential sources of PCE contamination at WS4 have shown the persistent and widespread presence of PCE in this deep groundwater. PCE is routinely measured in monitoring and private wells at levels near (and often above) the maximum contaminant level (MCL) of 5.0 micrograms per liter (μg/L). In some cases, private wells located outside of, but in the vicinity of, the defined Superfund site have been measured with much higher levels of PCE. None of the private wells in the vicinity of WS4 are known to be used for domestic purposes. All known private wells within approximately 1 mile of WS4 are on properties that are connected to city water for domestic water use. Property owners with known private wells in the vicinity of WS4 have been notified of the presence of PCE in groundwater; they have been told that their private wells should not be used to supply domestic water (for drinking or bathing) but can be used for activities such as irrigation and washing cars. At this time the EPA does not intend to include the wider contamination by PCE throughout the aquifer as part of the Superfund site.

There are no wetlands, flood plains, threatened or endangered species, or properties on or eligible for the National Registry of Historic Places on this site.

3.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The wellfield at WS4 has been owned by the City of Vancouver for over 50 years. The production wells at WS4 were installed during World War II to provide water for workers at the Vancouver Shipyards. Water from WS4 is blended together with water from several other wellfields to provide drinking water to the Vancouver region. The combined water supply system provides drinking water to approximately 150,000 people throughout the Vancouver area. Water from WS4 is primarily used to meet peak demand, particularly in the summer.

3.1 INITIAL RESPONSE

When the federal Safe Drinking Water Act (SDWA) was amended to require suppliers of public drinking water to monitor for volatile organic compounds (VOCs), the City of Vancouver began monitoring water from WS4 and its other wellfields. Results of this monitoring, which began in March 1988, indicated a persistent presence of PCE in the water at WS4. In February 1989, in consultation with the Washington State Department of Health (WDOH), the City notified the public of the presence of PCE in the groundwater at both Water Station 1 (WS1) and WS4. Because PCE concentrations at WS1 were much lower than those at WS4, the notice stated that WS1 water was being blended with WS4 water to reduce overall PCE concentrations.

In April of 1989, the four WS4 wells with the higher PCE concentrations were taken out of service. In May of 1989, EPA proposed an MCL for PCE for public drinking water systems of 5.0 µg/L. EPA issued the final MCL for PCE (5.0 µg/L) in January 1991, with an effective date of July 1992 (40 CFR Part 141). Samples collected from the production wells in the spring of 1989 showed concentrations of PCE ranging from approximately 3 to 10 µg/L.

3.2 INVESTIGATIONS

Several investigations into the source or sources of PCE at WS4 have been conducted by the City of Vancouver and EPA since PCE was detected at WS4 in 1988. The investigations began in 1989 by sampling private wells, surface water sources, and industrial sumps in the vicinity of WS4. Early investigations focused on dry cleaning operations on the Mill Plain plateau to the north (and upgradient) of WS4. PCE is commonly used as a solvent in dry cleaning, and dry cleaners are routinely considered in most investigations of an unknown source of PCE in groundwater.

Investigations of potential sources of PCE at WS4 included conducting soil-gas surveys, installing monitoring wells, and taking samples from monitoring and private wells in the vicinity of WS4. From 1989 through 1992 over 300 soil-gas samples were collected from hundreds of locations within the expected capture zone of WS4. The soil-gas results were inconclusive and although they did not identify any specific "hotspots," they were used to locate monitoring wells.

In 1990 the City of Vancouver installed seven monitoring wells at locations including Harney School, Dubois Park, East Fifth Street, and the Park Hill Cemetery. In 1992 EPA installed an additional eight monitoring wells and collected samples from the new wells and several existing monitoring wells. (The new wells were installed at locations covering a wide area to the north and northwest of WS4.) Between 1993 and 1997 the City of Vancouver installed and collected samples from another eight wells on the Mill Plain plateau. Two additional wells were installed by EPA as part of the final remedial investigation in 1998. Figure 3-1 shows the locations of wells in the vicinity of WS4.

The City of Vancouver has also routinely collected samples from the production wells at WS4. Since 1988, more than 1,500 weekly samples have been collected and analyzed for PCE. (The production well samples have been analyzed only for PCE, but all monitoring well samples have been analyzed for the full suite of VOCs.)

3.2.1 Results of Investigations

The groundwater data clearly indicate that a pulse, or concentrated volume, of PCE passed through the wellfield over a period of several years beginning in 1992. PCE concentrations suddenly increased in 1992, peaked in about 1993, and decreased over the next several years to the current level (in the range of 20 to 40 µg/L). Concentrations of PCE at WS4 have ranged from a low of less than 1 µg/L to a maximum of 520 µg/L. Although PCE has been measured in all WS4 production wells, the highest average concentrations have measured in WS4-1, WS4-4B, and WS4-9. These production wells are located at the northern portion of the wellfield. Production wells WS4-2B and WS4-5B, both on the southern portion of the wellfield, have the lowest average concentrations. (These are the only two wells that have been used for water production since 1989.) WS4-3B, located in approximately the middle of the wellfield, shows a concentration trend over time that is higher than the two southern wells but lower than the three northern wells.

A similar pulse of PCE passed through PW-2, a private well located approximately 200 yards northeast (and upgradient) of the wellfield. The highest concentrations of PCE measured in this investigation were in PW-2 (concentrations of over 1,000 µg/L were routinely measured in PW-2 during 1991 and 1992). The City of Vancouver pumped PW-2 for several years (disposing of the water to the sewer system) in an effort to reduce the PCE entering the WS4 wellfield.

3.2.2 Sources of PCE

The available data indicate that multiple sources of PCE may be present in the area. (PCE has been detected in every deep monitoring well near WS4.) However, the sustained concentrations of PCE measured at PW-2 and at WS4 (both relatively close to each other) were many times greater than the maximum concentration measured at any monitoring well in the vicinity. Accordingly, as used in this Record of Decision, the term "source" refers to a source that could be either (1) primarily responsible for the sustained high concentrations of PCE measured at WS4, or (2) subject to cleanup or other source control measures. Using this definition, no primary, ongoing source of the PCE in WS4 was ever identified. However, the significant reduction in

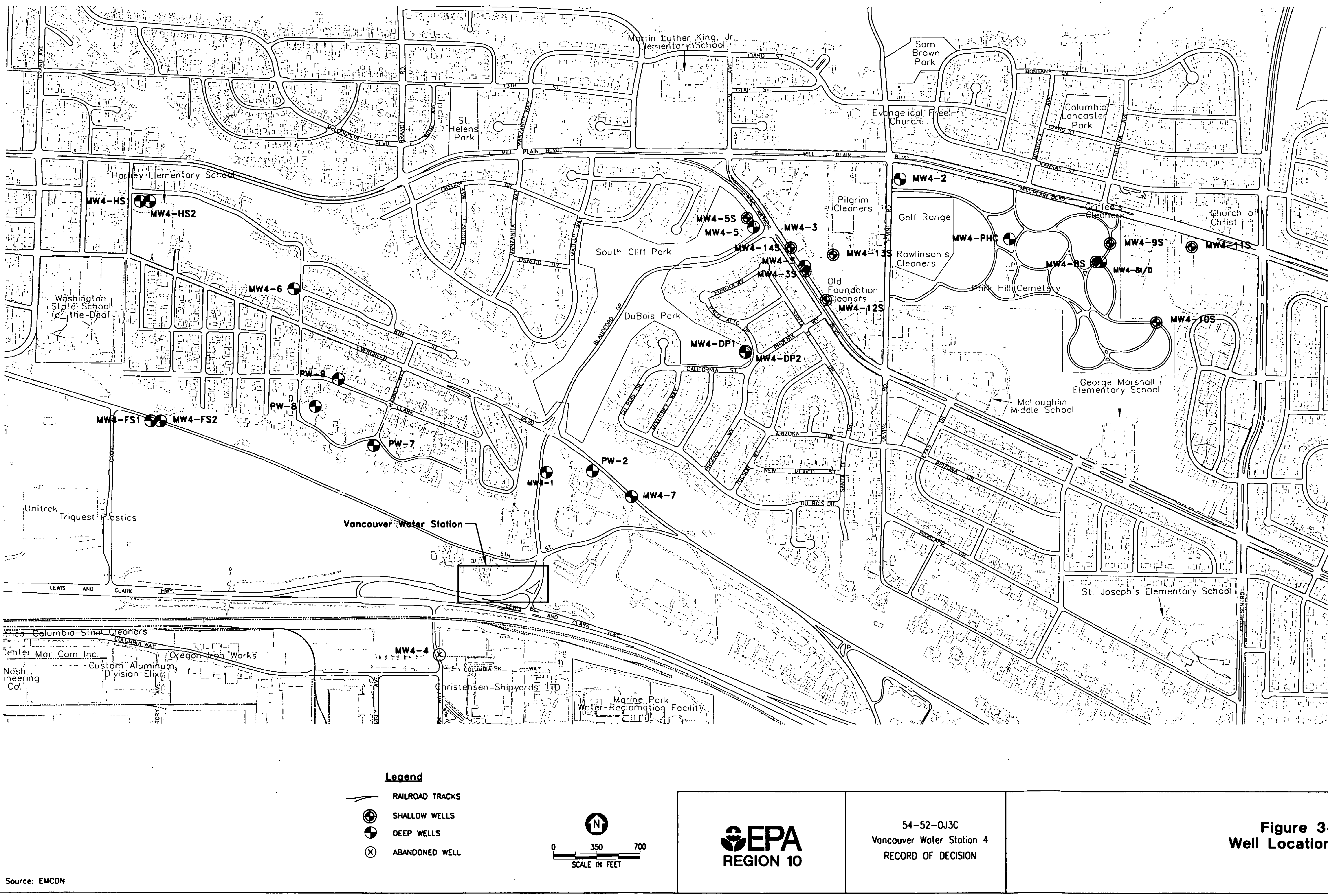

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Figure 3-1
Well Locations

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PCE concentration over the last several years strongly supports the conclusion that there is not an ongoing source of PCE contamination in the area.

3.3 INSTALLATION OF THE AIR STRIPPING SYSTEM

In October 1988, the City began weekly monitoring of the water at each of the six wells at WS4. The City used the results to determine which wells to use for drinking water production to ensure that the concentration of PCE in the drinking water delivered to its customers was as low as possible. In November 1989, the City removed WS4 from service.

To regain full use of WS4, the City installed an air stripping system to remove PCE from the groundwater pumped by the station. During the initial design of the air strippers, the concentration of PCE at WS4 was consistently in the range of 5 to 20 μg/L, so the stripper design was based on a maximum expected concentration of 100 μg/L. During 1991, however, the concentration of PCE in PW-2 rapidly increased to over 1,000 μg/L. This upgradient well was being sampled weekly to provide an "early warning" of possible increasing concentrations of PCE at WS4. Because of this increase, the City modified the design of the treatment system to accommodate an input concentration of more than 100 μg/L. The two stripping towers, originally designed to run in parallel and to treat 8,000 gallons per minute (gpm), were re-configured to run in series. This design change reduced the total flow to 4,000 gpm, but enabled the system to remove much higher concentrations of PCE.

The redesigned treatment system was put into operation in January 1992, and has reduced concentrations of PCE in treated water to below detectable levels. Only two of the six wells at the water station—the two with the lowest average concentrations of PCE—have been used since the station resumed service in 1992.

Following installation of the air stripping treatment system, the City changed the frequency of its monitoring of the untreated water from weekly to monthly.

3.4 ENFORCEMENT

Although the air stripping system was effectively removing PCE from water that the City was distributing for drinking water, Vancouver WS4 was listed on the NPL in October 1992 because of the presence of PCE in the groundwater. The maximum detected PCE concentration reported from a production well was 520 μg/L, reported on July 6, 1993, from WS4-9.

As required under CERCLA, a preliminary health assessment was conducted by WDOH under cooperative agreement with the U.S. Department of Health and Human Services' Agency for Toxic Substances and Disease Registry. Released for public comment in April 1993, the preliminary health assessment evaluated only the effects of exposure to untreated PCE-contaminated water. The assessment identified one community health concern: the risk of cancer from drinking water contaminated with PCE. However, at the time that the assessment was prepared, the carcinogenicity of PCE was still under review by EPA and the assessment could state only that the likelihood of developing cancer as a result of lifetime exposure to PCE-contaminated water associated with WS4 could not be estimated. The assessment also concluded that the site posed no apparent public health hazard to the known exposed population as a result of short-term exposure to elevated PCE concentrations in water.

In September 1993, federal funding constraints led to a decision by EPA to postpone further investigations of WS4, saving EPA's limited funding for sites with greater risk. (The threat to human health had been eliminated by the treatment system, which was fully operational in 1992.)

In November 1997, EPA resumed work on the investigation of WS4. In March 1998, EPA collected samples from existing monitoring wells and private well PW-2. In September 1998, EPA installed two additional monitoring wells and collected samples from monitoring and private wells in the vicinity of WS4. Samples were collected using low-flow techniques and were analyzed for the full suite of VOCs. PCE concentrations ranged from 1.1 to 19.9 μg/L in the March 1998 sampling and from 1.1 to 25.6 μg/L in the September sampling. Eighteen wells were sampled on both occasions; concentrations in 7 of these wells did not significantly vary from March to September, concentrations increased in 7 wells, and concentrations decreased in 4 wells.

In 1999, EPA released the final remedial investigation and feasibility study (RI/FS) report for WS4. The results of the RI/FS report are summarized in this Record of Decision (ROD).

4.0 COMMUNITY RELATIONS

4.1 CITY OF VANCOUVER COMMUNITY RELATIONS EFFORTS

In February 1989 the City of Vancouver notified users of public water that PCE had been detected in wells at WS4. The notice stated that the City was reducing the amount of water pumped from WS4 and increasing the amount of water pumped from WS1 to reduce the concentration of PCE in water delivered to its customers. In November 1989, the City took WS4 out of service until a treatment system could be installed.

In response to the water quality concerns at WS4, in 1989 the City began providing its water customers with an annual water quality report that it included with each customer's March billing statement. The contamination at WS4 was the subject of the first report.

Also in response to the water quality concerns at WS4, in 1989 the City sponsored formation of the Water Quality Advisory Committee, which includes medical and legal experts, members of the community, state regulators, and representatives from the City's water department. The Advisory Committee serves as a forum through which the City disseminates technical information to the public and receives input regarding the community's concerns. The Advisory Committee issues recommendations to the City's Public Works Director and was instrumental in designing the City's policy for notifying the public about water quality incidents.

4.2 EPA COMMUNITY RELATIONS EFFORTS

EPA issued a fact sheet in July 1992 entitled "Vancouver Water Station #4 Contamination Superfund Site." This fact sheet described the startup of the air stripping system and announced plans to install monitoring wells in the vicinity of WS4 and to begin scoping for the remedial investigation.

In October 1992, EPA issued a news release announcing that WS4 had been added to the NPL as a Superfund site.

EPA's "Superfund Community Relations Plan" for the WS4 Superfund site was released to the public on February 1, 1993. The plan noted that 32,000 copies of the July 1992 fact sheet had been distributed and that EPA had met with members of the community on September 21 and 22, 1992. The plan also announced establishment of an information repository at the Fort Vancouver Regional Library and stated that many Vancouver neighborhood associations and other local organizations had been placed on EPA's mailing list.

In September 1993, EPA distributed another fact sheet entitled "Vancouver Water Station #4 Contamination Superfund Site," announcing the postponement of the investigation of WS4 to give funding priority to other sites with more immediate health risks and noting that monitoring would continue while the investigation was on hold.

In September 1994, EPA released another fact sheet, entitled "Vancouver Water Stations #1 and #4 Contamination Sites," reiterating the postponement of the investigation at WS4 and noting that the investigation at WS1 was also on hold.

The most recent fact sheet was released June 18, 1998, and provided summaries of previous activities at both WS1 and WS4. The fact sheet noted that the Proposed Plan for WS1 was expected to be issued in July 1998, with the Proposed Plan for WS4 "to be developed early" in 1999.

The RI/FS report for WS4 was released in May 1999 and made available to the public in the Administrative Record maintained at EPA Region 10, 1200 Sixth Avenue, Seattle, Washington, and at the information repository maintained at the Vancouver Public Library, Fort Vancouver Branch, 1007 E. Mill Plain Boulevard, Vancouver, Washington. The Proposed Plan for WS4 was published on May 5, 1999. The notice of availability of these two documents was published in the *Vancouver Columbian* on May 5, 1999.

The public comment period was held from May 5, 1999, to June 3, 1999. Written comments on the Proposed Plan and RI/FS report were received from two individuals and the City of Vancouver. The community had an opportunity to request a public meeting during the public comment period on the Proposed Plan, but no requests for a public meeting were received.

This decision document presents the selected remedial action for the WS4 site in Vancouver, Washington, chosen in accordance with CERCLA, as amended, and, to the extent practicable, the NCP. The decision for this site is based on the Administrative Record.

5.0 SCOPE AND ROLE OF RESPONSE ACTION

This site consists of one operable unit. The selected remedy is the final action at this site.

The City of Vancouver and EPA conducted numerous investigations prior to the remedial investigation, spanning a period of 10 years, to identify the source of PCE entering WS4, but an ongoing source (or sources) of the PCE contamination for which cleanup action could be taken was never identified. Although it appears that a pulse of higher-concentration PCE passed through the water station, a definitive PCE plume has not been delineated. No additional investigation into potential sources was conducted during the remedial investigation because concentrations at WS4 had decreased substantially and there was no evidence of an ongoing source area where cleanup action could be taken.

The response action is therefore focused on the groundwater at the wellfield and on ensuring that the drinking water distributed by WS4 meets the standards that are protective of human health. The scope of the response action at WS4 is the following:

- Ensuring that human health is protected by reducing the level of PCE in drinking water produced from WS4 to meet federal drinking water standards

- Reducing the concentration of PCE in the groundwater at WS4 to below the MCL of 5 µg/L

EPA's response action for WS4 is to select the continued treatment of drinking water produced from WS4 by using the air stripping treatment system that is already in operation. Continued operation of the air stripping treatment system at WS4 to provide clean drinking water will also serve as a treatment system for the contaminated groundwater at the wellfield.

6.0 SUMMARY OF SITE CHARACTERISTICS

6.1 PHYSICAL CHARACTERISTICS

6.1.1 Surface Features

The Vancouver area is situated on a series of gentle terraces rising to the north from the Columbia River. WS4 is located about ½ mile north of the Columbia River, near the first terrace above the Columbia River flood plain at an elevation of approximately 100 to 110 feet above mean sea level (msl). Topography is flat with a gentle slope to the west. South of the site, the ground surface slopes down to the flood plain, which is at an elevation of approximately 30 feet above msl. North of the site, the ground surface slopes steeply upward to elevations of approximately 250 to 300 feet above msl at the top of the second terrace north of the Columbia River. This terrace is located roughly at Mill Plain Boulevard and is referred to as the Mill Plain plateau.

Water Station 4 is located within a fenced area in a neighborhood that also includes single and multifamily residences and small commercial businesses to the west, north, and east. The Lewis and Clark Highway is south of the site. Paved areas are typically equipped with stormwater drains, which are part of the city's stormwater system.

6.1.2 Geology

The geological setting of the Vancouver area consists of 2,000-foot thick Cenozoic-Age basaltic basement rock overlain by Miocene to Pliocene Age sedimentary bedrock units (the Lower and Upper Members of the Troutdale Formation), topped with Pleistocene to Holocene Age unconsolidated alluvial sediments.

The sediments of the Upper Member of the Troutdale Formation contain a lower layer of coarse-grained sandy gravel and an upper layer of cemented gravel. A period of erosion and weathering followed deposition of the Troutdale Formation, resulting in a highly weathered zone at the top of the Troutdale Formation and a thin soil horizon. The Pleistocene alluvium of the Orchards Gravel overlies the Troutdale Formation. The Orchards Gravel is composed of coarse-grained sand and gravel in the area of the Columbia River flood plain with finer-grained sands present as lenses and/or stringers within the coarse-grained material in the terraced areas.

Lithology in the wider vicinity around WS4 is dependent upon location. Boring logs for wells in the Mill Plain plateau describe sand with variable amounts of silt and gravel (Orchards Gravel) to depths ranging from approximately 130 to 140 beet below ground surface (bgs). A 3- to 7-foot-thick, low-permeability, sandy silt/clay with gravel is present below the sand that represents the weathered top of the Troutdale. Gravel with variable amounts of sand and silt is present beneath the silt/clay unit to depths in excess of 300 feet bgs.

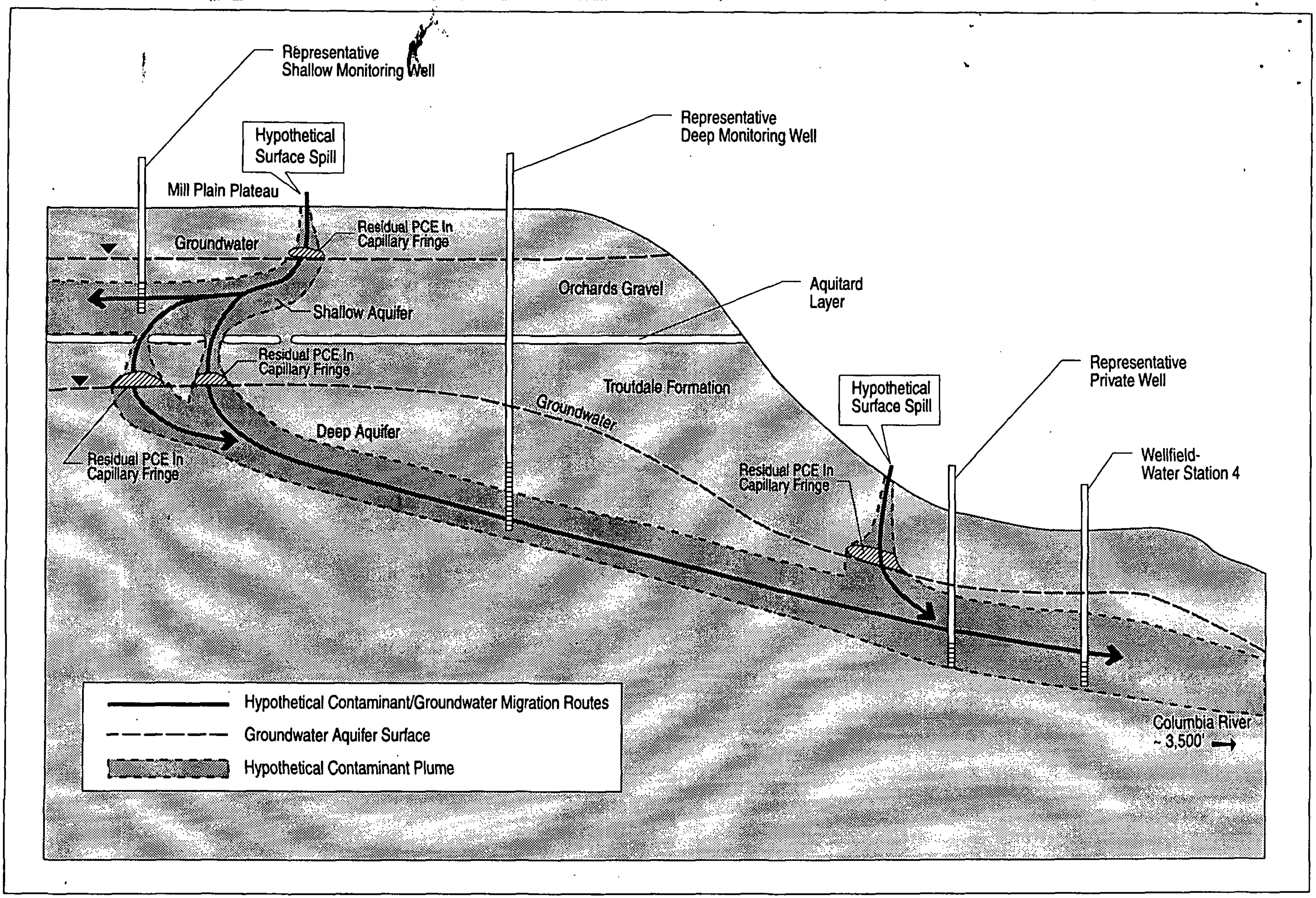
Boring logs for wells in the immediate area of WS4 describe silty sand with minor amounts of gravel to depths of approximately 80 feet bgs. A gravelly silt to clay is present from approximately 80 to 130 feet bgs in the western portion of the area (data from MW4-6) that thins to the east (data from MW4-4). These sediments are assumed to be alluvial deposits from the Columbia. The Troutdale is observed below the alluvial sediments. The weathered top of the Troutdale does not appear to be present in the lower elevations (i.e., elevations similar to those of WS4) at the base of the Mill Plain bluff.

The physical conceptual site model (Figure 6-1) is based on an interpretation of the geological data that concludes that the weathered top of the Troutdale was eroded in the area between WS4 and the top of the Mill Plain plateau by the Columbia River prior to the deposition of the Orchards Gravel. Wells installed in the Mill Plain plateau to the north of WS4 provide strong support for the conclusion that the Orchards Gravel is prominent on the plateau, but not present at the lower terrace occupied by WS4.

6.1.3 Hydrogeology

Groundwater in the Vancouver area is produced primarily from two formations, the Orchards Gravel (also referred to as the shallow groundwater zone) and the lower portion of the Upper Member of the Troutdale Formation (referred to as the deep groundwater zone). Production wells at WS4 are screened in the deep groundwater from either the Troutdale Formation or alluvium in direct hydraulic communication with the Troutdale Formation.

WS4 produces groundwater from a gravel unit within the lower portion of the Upper Member of the Troutdale Formation. This deeper groundwater formation extends approximately from 200 to



EPA REGION 10	**Figure 6-1** **Physical Conceptual Site Model**	54-52-OJ3C Vancouver Water Station 4 RECORD OF DECISION

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250 feet bgs and is known to be present below the Mill Plain plateau, with a hydraulic gradient to the south-southwest toward the Columbia River. Specific capacities are reported to exceed 300 gallons per minute per foot of drawdown, and the individual production well yields range from 600 to 2,000 gallons per minute.

The areal extent of the shallow groundwater zone is not known, although it is known to exist in the Mill Plain plateau, specifically in the area of the Tower Mall shopping center. The shallow groundwater zone is found at a depth of about 120 feet bgs and is generally about 10 to 20 feet thick. Apparent groundwater flow in this perched zone is to the west. Based on boring logs developed during site investigation activities, the Orchards Gravel does not appear to provide a potential for significant water resources in the immediate area of WS4.

6.2 NATURE AND EXTENT OF CONTAMINATION

PCE is the primary chemical of concern, although acetone and bromoform have also been detected.

6.2.1 Chemicals of Potential Concern

PCE is the only chemical of potential concern (COPC) identified in untreated water from production wells, monitoring wells, or private wells in the vicinity of WS4 because it is the most frequently detected chemical and is detected at concentrations significantly greater than the risk-based screening concentration (RBSC). The RBSC is equal to 1×10^{-6}, using EPA standard exposure assumptions for drinking water use. Other detected chemicals, as well as chemicals that were not detected but that had sample quantitation limits greater than the RBSCs, were eliminated from further evaluation for one or more of the following reasons:

- The chemical was infrequently detected or not detected in any sample (e.g., bromoform in production wells; 1,1,1-trichloroethane in deep wells; and acetone in shallow wells). Numerous volatile organic compounds were analyzed for in samples collected but were never detected.

- The chemical was detected at concentrations less than the RBSCs (e.g., bromoform in production wells; 1,1,1-trichloroethane in deep wells; acetone in shallow wells).

- The chemical was detected at concentrations greater than the RBSCs, but the magnitude of the exceedance was not great, or the concentration has decreased to less than the RBSCs during recent sampling events (e.g., chloroform in deep wells; benzene in shallow wells).

- Available data from prior to 1996 may not be representative of current conditions because of changing groundwater conditions over time.

6.2.2 Acetone Detections

Although PCE was the only COPC for the WS4 site, acetone was recently detected at elevated concentrations in the groundwater beneath the Mill Plain plateau. In September 1998, acetone was detected in samples from five wells (MW4-DP1, MW4-DP2, MW4-5S, MW4-14S, and MW4-PHC). At four of these five wells, the detected concentrations of acetone were much less than the RBSC of 3,650 µg/L. (An MCL for acetone has not been established.) In MW4-PHC, however, the reported concentration of acetone was 42,600J µg/L. Because acetone had not previously been detected in this well, and had never been detected at any elevated concentration in a monitoring well in the vicinity of WS4, MW4-PHC was resampled in January 1999. The concentration of the sample collected in January was 930 µg/L, less than the RBSC but still higher than any other detected concentration of acetone in wells near WS4. The elevated concentrations of acetone in MW4-PHC are too high to have been caused by laboratory contamination. (Acetone is commonly used as a solvent in laboratory extractions, so low levels of acetone detected in environmental samples are often attributed to laboratory contamination.) Accordingly, these concentrations are probably representative of actual groundwater conditions.

The City of Vancouver has been notified about the detected concentrations of acetone in groundwater at the Mill Plain plateau. The City has indicated that it will begin monitoring for acetone in samples routinely collected from production wells at WS4. (The current practice is to analyze these samples only for PCE). Further investigation into the acetone detected in MW4-PHC is not being pursued under EPA's investigation of the PCE contamination at WS4 for the following reasons: (1) acetone was detected only recently and has no apparent relationship to the historical releases of PCE, (2) acetone was detected in the Mill Plain area only at low concentrations (except for MW4-PHC), (3) MW4-PHC has shown a significant decrease in acetone over a 4-month period, and (4) acetone is both miscible in water and readily biodegradable, and therefore is unlikely to reach WS4 in concentrations approaching the RBSC of 3,650 µg/L.

Therefore, PCE is the only chemical evaluated in the remedial investigation.

6.2.3 PCE Concentrations

Summaries of PCE concentrations are presented by medium in the following paragraphs.

Soil-Gas

Soil-gas sampling was conducted in early investigations to identify PCE "hotspots," particularly near the existing and former dry cleaning facilities on the Mill Plain plateau. When the concentrations of PCE began to increase at WS4 productions wells and at PW-2, additional soil-gas sampling was conducted in the PW-2 area. The results were useful in helping locate potential sites for monitoring well installation, even though none of the concentrations were considered indicative of an ongoing PCE source area for which cleanup action could be taken.

Soil

Approximately 100 soil samples were collected from a range of depths during installation of six monitoring wells in the vicinity of WS4. Additionally, surface soil samples were collected from five locations in the vicinity of the dry cleaning businesses on the plateau. Relatively few soil samples were collected so the lateral coverage of soil data across the area is therefore limited. However, laboratory-reported analytical results from these samples do not show significant detections of PCE or degradation products.

Groundwater

To evaluate the extent of PCE contamination, existing groundwater data for the site were separated into the following three data sets based on well location and the groundwater formation in which the well is screened:

- WS4 production wells
- Wells completed in the deep aquifer (Troutdale Formation)
- Wells completed in the shallow aquifer (Orchards Gravel)

Results for these three groups of wells are discussed in the following subsections.

Production Wells. WS4 consists of six active production wells and one inactive well. The six active wells, which are all screened at approximately the same depth, are dispersed over a large portion of the well field. Two of the active production wells (WS4-2B and WS4-5B), both located in the southern portion of the well field, have had historically the lowest concentrations of PCE. These are the only wells from which water has been produced by WS4 since 1989. PCE concentrations in the four remaining active wells (WS4-1, WS4-3B, WS4-4B, and WS4-9) have varied over time, but are generally consistent with the overall wellfield pattern of sudden increase and gradual decrease in PCE concentrations.

It is not known to what extent the pattern of higher concentrations of PCE in the northern portion of the wellfield (and lower concentrations in the southern portion) are related to the location of the release(s) of PCE responsible for contamination at WS4. Although an ongoing source for which cleanup actions could be taken has not been identified, the concentration of PCE in every production well has significantly decreased over the last several years.

A summary of PCE detections in WS4 production wells, including maximum and minimum concentrations and the total number of samples compared to the number of samples exceeding the MCL of 5.0 µg/L, is provided in Table 6-1.

Deep Wells. Concentrations of PCE in the 16 deep monitoring wells and 4 deep private wells in the vicinity of WS4 vary considerably over time and by location. Low concentrations of PCE (but still above the MCL of 5.0 µg/L) appear to be widespread in the deep groundwater; PCE has been detected in every deep well in the vicinity of WS4 and has been measured in concentrations above the MCL in 17 of the 20 wells used in this evaluation.

The highest concentration of PCE measured in any well during the investigations was 1,600 µg/L at PW-2, a deep private well located about 200 yards upgradient of the wellfield. The next highest concentration in a deep well was 145 µg/L, at private well PW-9 about ½ mile northwest of WS4. The highest concentration of PCE measured in a deep well on the Mill Plain plateau was 66.7 µg/L, at MW4-DP2.

These maximum concentrations do not appear to be part of any common plume. Two deep monitoring wells were installed near PW-2. MW4-7, located a few hundred feet east of PW-2, had the highest detected concentration of PCE in any of the monitoring wells sampled during the investigations (100 µg/L in 1992). However, concentrations in MW4-1, located a few hundred feet west of PW-2, have all been below the MCL. This is strong evidence that a high-concentration PCE plume was not widespread and was limited to a relatively narrow channel that was intercepted by PW-2.

A summary of PCE detections in the deep-zone wells, including maximum and minimum concentrations and the total number of samples compared to the number of samples exceeding the MCL of 5.0 µg/L, is provided in Table 6-1.

Table 6-1
Summary of PCE Detections in Groundwater (1988-1998)

Well ID[a]	Minimum Detected PCE (µg/L)	Date Detected	Maximum Detected PCE (µg/L)	Date Detected	Detections/ Total Samples	Exceedances/ Total Samples
Production Wells						
WS4-1	5.2	1989	370	1992	290[a]	290/290
WS4-2B	0.98	1990	380	1993	287[a]	287/287
WS4-3B	3.6	1989	450	1992	258[a]	258/258
WS4-4B	15.9	1997	390	1992	294[a]	291/294
WS4-5B	0.24	1990	501	1993	293[a]	292/294
WS4-9	8	1998	520	1993	276[a]	271/276
Deep Wells						
MW4-1	0.6	1997	1.8 J	1998	5/5	0/5
MW4-2	0.6	1997	1.3	1992	3/5	0/5
MW4-3	12.1	1998	17	1997	4/5	4/5
MW4-4	11	1989	11	1992	1/2	1/2
MW4-5	19.9	1998	50	1992	5/5	5/5
MW4-6	2	1998	5.7	1992	3/3	1/3
MW4-7	1.3	1997	100	1992	5/5	4/5
MW4-8D	8.6	1998	8.6	1998	1/6	1/6
MW4-8I	0.7	1996	1.1	1997	5/6	0/6
MW4-DP1	0.37	1990	9.8	1998	7/10	2/10
MW4-DP2	2.2	1998	66.7	1990	18/18	17/18
MW4-FS1	3.99	1990	18.8	1992	7/7	4/7
MW4-FS2	2.01	1990	7.2	1998	6/6	2/6
MW4-HS1	0.9	1990	7.45	1992	14/15	9/15
MW4-HS2	0.61	1990	5.71	1991	4/6	2/6
MW4-PHC	1.45	1990	5.5	1991	9/11	1/11
PW-2	0.2	1989	1,600	1992	262[b]	205/262
PW-7	7.9	1990	93	1992	7/7	7/7
PW-8	11.6	1998	55	1989	5/5	5/5
PW-9	0.77	1990	145	1992	5/5	4/5
Shallow Wells						
MW4-3S	3.2	1998	55	1992	5/5	3/5
MW4-5S	5.5	1998	5.5	1998	1/1	1/1
MW4-8S	1.6	1996	23	1997	8/8	5/8

Table 6-1 (Continued)
Summary of PCE Detections in Groundwater (1988-1998)

Well ID[a]	Minimum Detected PCE (µg/L)	Date Detected	Maximum Detected PCE (µg/L)	Date Detected	Detections/ Total Samples	Exceedances/ Total Samples
MW4-9S	2.5	1998	9.7	1997	7/7	5/7
MW4-10S	ND		ND		0/5	0/5
MW4-11S	1.1	1998	3.6	1997	3/4	0/4
MW4-12S	2.9	1998	4.9	1998	2/2	0/2
MW4-13S	1.8	1998	2.5	1998	2/2	0/2
MW4-14S	2.8	1998	2.8	1998	1/1	0/1

[a]Well locations are shown in Figure 3-1.
[b]Number of samples in provided data set. Documentation not provided to evaluate nondetects.

Notes:
Exceedance - equal to or greater than 5 µg/L
µg/L - micrograms per liter or part per billion (ppb) equivalent
ND - not detected
PCE - tetrachloroethene

Shallow Wells. Nine monitoring wells have been installed in the shallow groundwater zone at locations near or downgradient from former and current dry cleaning operations on the Mill Plain plateau (including four installed during 1998). These wells were installed in an attempt to identify the shallow groundwater plume of PCE that would have first materialized if a surface release of PCE was moving down through the soil column.

The maximum PCE concentration (55 µg/L) was observed in a water sample collected from shallow well MW4-3S in October 1992. The well is located directly downgradient from current and historical dry cleaning facilities in or near the Tower Mall. Concentrations of PCE in this well have steadily decreased over the last 6 years and in 1998 were below the MCL.

PCE concentrations exceeding the MCL (23 µg/L at MW4-8S and just under 10 µg/L at MW4-9S) had been observed in 1997, but at both locations concentrations were below the MCL in the 1998 sampling. Only one of the four remaining wells has had a detection of PCE that slightly exceeded the MCL (5.5 µg/L at MW4-5S). PCE concentrations detected during the September 1998 sampling at newer wells MW4-13S and MW4-14S were 2.5 and 2.8 µg/L, respectively.

A summary of PCE detections in the shallow-zone wells, including maximum and minimum concentrations and the total number of samples compared to the number of samples exceeding the MCL of 5.0 μg/L, is provided in Table 6-1.

7.0 SUMMARY OF SITE RISKS

Typically, a baseline risk assessment is conducted during the remedial investigation at an NPL site. A baseline risk assessment is an analysis of the potential adverse health effects caused by hazardous substance releases from a site in the absence of any actions to control or mitigate these releases. WS4 differs from the typical NPL site in that remedial action (air stripping treatment of drinking water produced from WS4) has already been implemented. Because of this, the human health risk assessment (HHRA) for WS4 evaluates both an action alternative (treatment of water by air stripping, the current situation) and a no-action alternative (a potential future scenario that could occur if air stripping were to be discontinued). The HHRA is summarized in Section 7.1.

An ecological risk assessment is a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. At WS4, the stressor consists of PCE in the groundwater, which occurs at a depth of about 200 feet below ground surface. As discussed further in Section 7.2, no exposure pathway to PCE in groundwater has been identified for ecological receptors.

7.1 HUMAN HEALTH RISK ASSESSMENT

An HHRA was performed to evaluate risks to residents of Vancouver who use water produced from WS4 as their primary source of drinking water. The risk assessment consists of four main components:

- Identification of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

These components are summarized in Sections 7.1.1 through 7.1.4. The qualitative uncertainty analysis is summarized in Section 7.1.5.

7.1.1 Identification of Chemicals of Potential Concern

In accordance with EPA Region 10 guidance, a risk-based screening approach was used to identify COPCs in drinking water at WS4. The chemical screening consisted of comparing concentrations of chemicals detected in groundwater at WS4 to risk-based screening concentrations established by EPA. In untreated water from production wells, monitoring wells, or private wells, PCE was identified as the only COPC because it is the most frequently detected chemical and is detected at concentrations significantly greater than the risk-based screening concentration (RBSC). No COPCs were identified in treated water.

7.1.2 Exposure Assessment

The exposure assessment identifies potential receptors and estimates the type and magnitude of exposures to the COPC (PCE) that was identified in Section 7.1.1. The results of the exposure assessment are then combined with the chemical-specific toxicity information (Section 7.1.3) to characterize potential risks (Section 7.1.4).

The four steps in exposure assessment are characterization of the exposure setting and potential receptors, identification of exposure pathways, development of exposure point concentrations, and quantification of chemical intakes.

Characterization of the Exposure Setting and Receptors

Three groups of receptors were evaluated:

- Future public water supply users
- Future private water supply users
- Current private water supply users

Identification of Exposure Pathways

The primary medium to which exposure may occur is groundwater. WS4 is one of several water stations that supply drinking water to people in the city of Vancouver and surrounding Clark County. Although there is a potential exposure pathway for current public water supply users (i.e., people using treated water produced by WS4), PCE has not been identified in the treated water and therefore the exposure pathway to these receptors is incomplete.

Three potentially complete exposure pathways (Figure 7-1) were evaluated:

- Future public use of untreated water from the production wells if treatment were to be discontinued

- Future private use of untreated groundwater from shallow or deep wells installed in the area around WS4 (represented by shallow and deep monitoring wells in this risk assessment)

- Current private use of untreated water from private wells near WS4 as a drinking water source

Potential exposure pathways for area residents using untreated water as a drinking water source include ingestion of PCE in untreated water, inhalation of PCE in untreated water during household use of water, and dermal contact with PCE in untreated water during bathing.

Significant exposures to untreated water by on-site workers are not expected to occur (Figure 7-1). Water is transported through the water station and treatment units via pipes, making direct contact with untreated water by workers unlikely.

Potential exposures to PCE in air may occur as a result of stack or fugitive emissions from the air strippers. According to the Order of Authorization to Operate issued by the Southwest Air Pollution Control Authority in 1997 (Authorization No. 95CL-512), the combined air emissions of PCE from two air stripping columns will be controlled by four granular activated carbon canisters, and will not result in ambient air concentrations of PCE in excess of the applicable Small Quantity Emission Rates as provided in Washington Administrative Code (WAC) 173-460. The granular activated carbon canisters are designed to achieve better than 95 percent removal of PCE from the vapor phase. The emissions from the carbon canisters are released through a stack at a height of at least 12 feet above ground level. Therefore, although there will be some small release of PCE to the air, potential exposures to site workers or area residents are believed to be minimal.

Development of Exposure Point Concentrations

Exposure point concentrations are media-specific concentrations of a COPC that an individual may plausibly come into contact with. Exposure point concentrations were developed for the future residential scenarios using PCE data collected between 1996 and 1998 from untreated water from individual production wells at WS4 and monitoring wells installed in the vicinity during source investigations. Exposure point concentrations were developed for the current residential scenario using PCE data collected in 1998 from untreated water from private wells. It

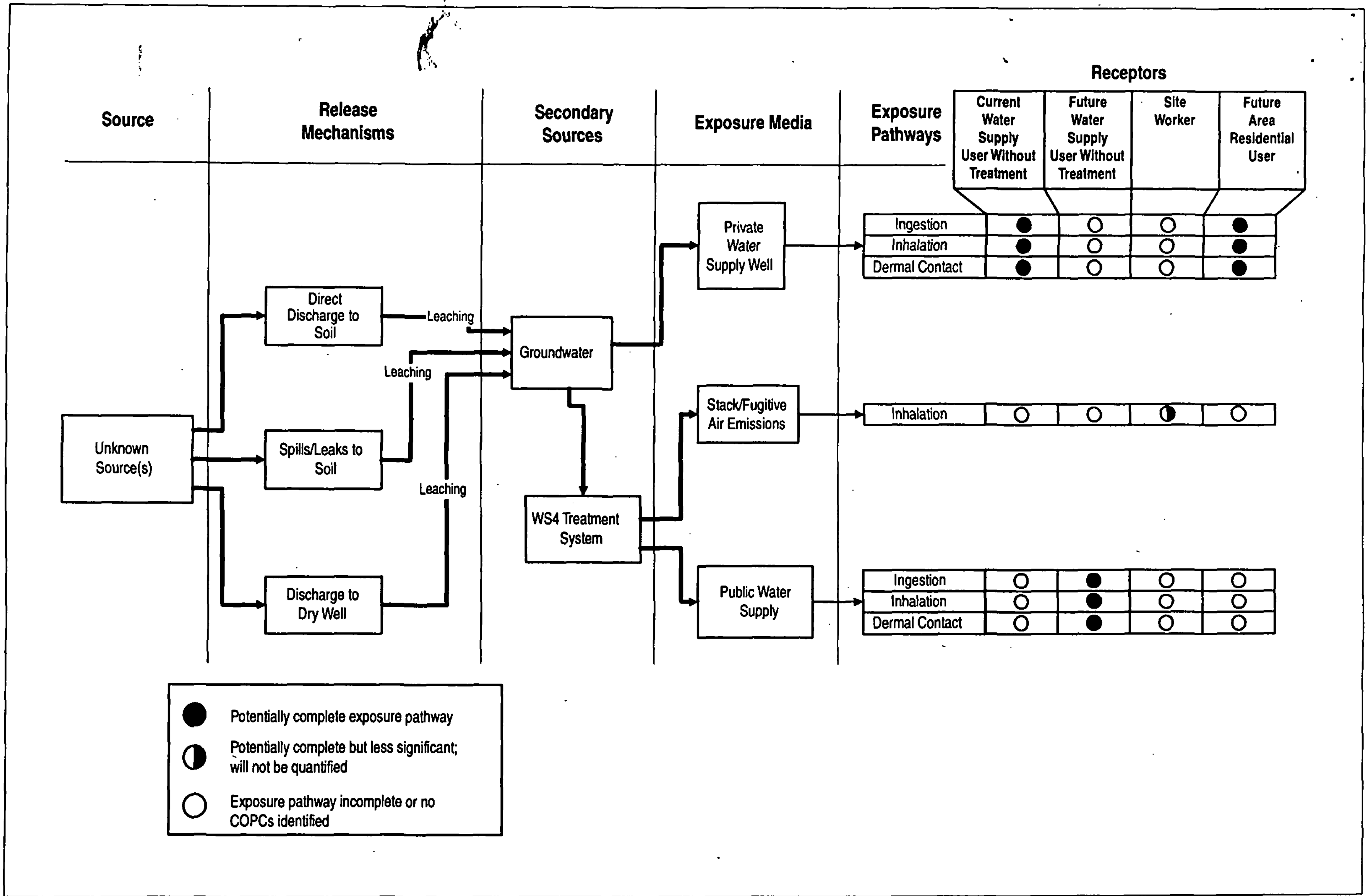


Figure 7-1
Human Health Conceptual Site Model

is conservatively assumed that the chemical concentrations remain constant over the assumed exposure periods (i.e., up to 30 years).

EPA guidance states that "because groundwater is a very complex and dynamic medium with characteristics that can change seasonally, it is likely that concentrations of a given contaminant in each well will vary over time. Therefore, the concentration term is best described by an arithmetic average [over time]...". Because of the uncertainty associated with estimating the true arithmetic mean from a limited number of samples, a degree of conservatism is needed in calculating exposure point concentrations. This conservatism is provided by using the 95 percent upper confidence limit (UCL95) on the arithmetic mean or by using the maximum detected value when the variability in the sampling results in a UCL95 that exceeds the maximum detected value. The methodology used to calculate exposure point concentrations for each of the three exposure pathways is described below.

Future Public Water Supply Users. An area of high PCE concentrations within the capture zone of WS4 was not identified. Therefore, the arithmetic average concentration (as represented by the UCL95) of PCE in each production well over time was used to characterize the range of potential future exposures to untreated groundwater from the production wells. Although PCE concentrations in the production wells appeared to be increasing in the late 1980s and early 1990s, concentrations have decreased significantly since the mid-1990s. Therefore, data collected during the previous 2 years (i.e., September 1996 through October 1998) were considered appropriate for use in this HHRA.

Future Private Water Supply Users. The available 1996 to 1998 data for monitoring wells installed in the shallow and deep aquifers at WS4 were used to estimate hypothetical future exposure concentrations for potential future users of untreated shallow aquifer and deep aquifer water. Maximum detected concentrations as reported from the 1996 or 1998 sampling events for the two location groups (shallow and deep) were used as exposure point concentrations.

Current Private Water Supply User. The available 1998 data for the four private wells located near WS4 were used to estimate current exposure concentrations for private well users. Specific uses of area private wells are unknown (e.g., drinking water, irrigation, industrial uses); therefore, the same exposure pathways assumed for the production well source were assumed for the private wells.

Quantification of Chemical Intakes

Chemical exposures, or intakes, were determined using exposure models that combine various exposure parameters related to behavior and physiology, such as exposure frequency and body weight, with exposure point concentrations. Reasonable maximum (or high end) exposures (RMEs) were evaluated for this HHRA.

The equations used to calculate intake from each exposure pathway are presented in the RI/FS report and are consistent with guidance from EPA Region 10. Exposures were calculated for adults only. EPA default exposure parameters were used to quantify these models; sources for the exposure parameters include EPA Region 10 supplemental guidance and EPA standard default exposure factors. Exposure is averaged over a lifetime (70 years, or 25,550 days) for carcinogens and over the exposure duration for noncarcinogens. A body weight of 70 kg was assumed for all exposure pathways.

7.1.3 Toxicity Assessment

Carcinogenic Effects

Chronic inhalation exposure of mice and rats to concentrations of PCE resulted in liver cell carcinomas in male and female mice, an increased incidence of mononuclear cell leukemia in male and female rats, and an increase of renal tubular cell tumors in male rats. No evidence of skin tumors was observed in a mouse skin initiation-promotion assay and no studies were located regarding cancer in humans after dermal exposure to PCE.

In evaluating cancer, the numeric descriptor of carcinogenic potency is termed a slope factor (SF). The slope factors for PCE are not available on the EPA Integrated Risk Information System (IRIS) database, although they are reported in EPA's *Risk Assessment Issue Paper for: Carcinogenicity Information for Tetrachloroethylene*. The oral slope factor as listed was 0.052 $(mg/kg\text{-}d)^{-1}$ and the inhalation slope factor was 0.002 $(mg/kg\text{-}d)^{-1}$ for PCE. The IRIS database is typically selected as the primary source of toxicity criteria when evaluating health risks or setting health-based cleanup goals because of the extensive research effort and scientific review. However, the National Center for Environmental Assessment (NCEA) serves as an adequate source if toxicity criteria are not available in IRIS.

Noncarcinogenic Effects

Chronic exposure to concentrations of PCE in air caused abnormal hepatic function, lightheadedness, headache, malaise, and dizziness in humans. Chronic occupational exposure to PCE in air causes significantly impaired functioning on neurobehavioral tests as compared to controls. In another study, dry cleaning workers exposed primarily to PCE in air exhibited minor liver and kidney changes. No studies on humans were found in the literature regarding chronic oral exposure to PCE.

For noncancer health effects, the toxicity values used in risk assessment are termed reference doses (RfDs). These are route- and duration-specific estimates of the average daily intake that can occur without appreciable risk of any adverse effects.

The chronic oral reference dose of 0.01 mg/kg-day for PCE was derived based on a 6-week gavage study in mice that resulted in liver toxicity. The uncertainty factor of 1,000 assigned to PCE accounts for intraspecies variability and extrapolation of a subchronic effect level to its chronic equivalent. The RfD confidence level is considered medium. Assuming a 100 percent oral-to-dermal adjustment factor, the dermal RfD value is the same as the oral RfD value. The inhalation RfD of 0.14 mg/kg-day used in the risk assessment was reported in EPA Region 9's preliminary remediation goal tables.

Dermal Toxicity Values

Calculation of risks from dermal exposures to groundwater requires dermal toxicity values. Dermal toxicity values must be based on the absorbed dose (rather than the exposed or administered dose), since dermal intakes are calculated as absorbed doses. Since EPA has not yet established any dermal toxicity values, approximate toxicity values were derived by extrapolation from oral toxicity values, assuming an oral absorption fraction of 1.

7.1.4 Risk Characterization

Risk characterization integrates the results of the exposure and toxicity assessments into a quantitative description of potential cancer and noncancer risks. The method for risk characterization used in this HHRA is consistent with EPA guidance.

The risk of cancer from exposure to a chemical is described in terms of the incremental probability that an individual exposed over his or her lifetime will develop cancer as a result of exposure to a potential carcinogen. The resulting probabilities may be expressed in numbers that indicate how many excess cancer cases are likely for a specified exposed population. For instance, an excess cancer risk of 1E-06 (or 1×10^{-6}) corresponds to one additional cancer case in an exposed population of 1,000,000 people. Similarly, an excess cancer risk of 1E-04 (or 1×10^{-4}) corresponds to one additional cancer case in an exposed population of 10,000. Excess cancer risks are summed across all COPCs and all exposure pathways that contribute to exposure of an individual in a given population. Typically, remedial action is warranted when total excess cancer risks to any population exceed EPA's acceptable risk range of 1E-06 to 1E-04 (40 CFR Part 300.430).

For current residents consuming treated water, no COPCs have been identified and therefore no excess cancers are expected to occur. Therefore no chemicals were identified as chemicals of concern (COCs) in treated water.

Cancer risks were calculated for residents using untreated water as the primary drinking water source. Results are summarized in Tables 7-1 through 7-3. Due to the inherent uncertainty in cancer risk calculations, total cancer risk values are reported to only one significant figure. Potential cancer risks to residents using untreated water range from 2E-05 to 5E-06. The cancer risks are attributed primarily to water ingestion and dermal contact with water. Even though these risks are within the NCP acceptable risk range, it is necessary to take an action at WS4 because groundwater has been shown to have persistent concentrations of PCE above the MCL.

Table 7-1
Summary of Cancer Risks
Future User of Untreated Public Water Supply

Location ID	Cancer Risk			
	Ingestion	Inhalation	Dermal Contact	Total
WS4-1	2.0E-05	2.9E-06	1.2E-05	4E-05
WS4-2B	1.8E-05	2.6E-06	1.1E-05	3E-05
WS4-3B	2.7E-05	3.9E-06	1.7E-05	5E-05
WS4-4B	2.6E-05	3.8E-06	1.6E-05	5E-05
WS4-5B	1.0E-05	1.5E-06	6.3E-06	2E-05
WS4-9	1.5E-05	2.1E-06	9.1E-06	3E-05

Table 7-2
Summary of Cancer Risks
Future Private Water Supply User

Location ID	Cancer Risk			
	Ingestion	Inhalation	Dermal Contact	Total
Shallow wells	1.6E-05	2.4E-06	1.0E-05	3E-05
Deep wells	2.3E-05	3.3E-06	1.4E-05	4E-05

Table 7-3
Summary of Cancer Risks
Current Private Water Supply User

Location ID	Cancer Risk			
	Ingestion	Inhalation	Dermal Contact	Total
PW-2	2.6E-06	3.8E-07	1.6E-06	5E-06
PW-7	1.1E-05	1.6E-06	6.8E-06	2E-05
PW-8	7.1E-06	1.0E-06	4.4E-06	1E-05
PW-9	7.4E-06	1.1E-06	4.7E-06	1E-05

The potential for noncancer health effects from exposure to a chemical is evaluated by comparing the estimated intake of a chemical over a specific time period with the RfDs for that chemical derived for a similar exposure period. This comparison results in a noncancer hazard quotient (HQ). Since exposure to PCE may occur simultaneously by more than one exposure pathway, HQ values are summed to obtain a hazard index (HI). If the total HI is equal to or less than 1, it is believed that there is no appreciable risk that adverse noncancer health effects will occur. If an HI exceeds 1, there is some possibility that adverse noncancer effects could occur, although an HI above 1 does not indicate an effect will definitely occur.

Potential noncancer hazard to residents using untreated water ranges from an HI of 0.02 to an HI of 0.2. Results are summarized in Tables 7-4 through 7-6. Since the total HI is less than 1 for all pathways evaluated, there is no appreciable risk that adverse noncancer health effects will occur.

Table 7-4
Summary of Noncancer Hazard
Future User of Untreated Public Water Supply

Location ID	Hazard Quotient			Hazard Index
	Ingestion	Inhalation	Dermal Contact	
WS4-1	0.089	0.024	0.056	0.2
WS4-2B	0.080	0.022	0.051	0.2
WS4-3B	0.12	0.032	0.076	0.2
WS4-4B	0.12	0.031	0.072	0.2
WS4-5B	0.045	0.012	0.028	0.09
WS4-9	0.065	0.018	0.041	0.1

Table 7-5
Summary of Noncancer Hazard
Future Private Water Supply User

Location ID	Hazard Quotient			Hazard Index
	Ingestion	Inhalation	Dermal Contact	
Shallow wells	0.074	0.020	0.046	0.1
Deep wells	0.10	0.027	0.064	0.2

Table 7-6
Summary of Noncancer Hazard
Current Private Water Supply User

Location ID	Hazard Quotient			Hazard Index
	Ingestion	Inhalation	Dermal Contact	
PW-2	0.012	0.0032	0.0074	0.02
PW-7	0.049	0.013	0.031	0.09
PW-8	0.032	0.0085	0.020	0.06
PW-9	0.033	0.0090	0.021	0.06

7.1.5 Uncertainty Assessment

There are a number of factors that can introduce uncertainty into any exposure and risk estimate. The key factors and assumptions that contribute to uncertainty in this risk assessment are summarized in the following discussion.

The estimates of risk in this assessment were based on the results of analytical data from several separate sampling rounds. Although different analytical laboratories may have been used, it is assumed that they used standard methods and followed similar quality control measures. Although the possibility exists for interlaboratory differences in measuring contaminant concentrations, this uncertainty is not expected to be large.

Water samples collected from the production wells were pulled from the turbine pumps and therefore some PCE may have volatilized during sample collection. EPA Superfund protocols recommend sampling for VOCs under low-flow conditions to minimize loss of VOCs during sampling. The effect of these sampling methods on concentrations of PCE is not known;

however, they may result in an underestimate of PCE concentrations and the corresponding human health risk.

Because an ongoing source (or sources) of PCE in the groundwater for which cleanup action could be taken have not been defined, there is considerable uncertainty associated with the potential PCE concentrations in off-site wells. It is possible that areas or pockets of groundwater with higher concentrations of PCE exist. If water from a private well in or near one of these areas was used for domestic water purposes, the potential risk to users of the water from these wells could be higher than those presented in the HHRA.

The RBSC comparison was designed to be conservative and the elimination of chemicals is not likely to result in a significant underestimate of risk. All data available from sampling of untreated water in 1989 through 1998 were used to determine COPCs. Due to the limited set of available data (the City of Vancouver tested regularly only for PCE at WS4), these data may not reflect the current concentrations of organic and inorganic contaminants other than PCE in untreated water.

In some cases, analytical procedures were not sensitive enough to detect chemicals potentially present at concentrations greater than RBSCs. For 1,1-dichloroethylene and vinyl chloride, high sample quantitation limits and their potential presence in the aquifer associated with WS4 may result in an underestimate of risk.

The evaluation of human health risks for the future resident used arithmetic average concentrations in untreated water over a period of time from 1996 through 1998. It is not known whether concentrations will decline over the long term as natural attenuation processes reduce the concentrations of the COPCs, which would decrease risk, or whether input from existing or potential future sources may result in an increase in water concentrations of VOCs, which would increase risk. Therefore, potential future risks may be over- or underestimated. The magnitude of this over- or underestimate cannot be determined with available information (although the data available appear to indicate that the PCE contamination at WS4 peaked in the early 1990s and has steadily decreased since then).

The daily intakes in this risk assessment were calculated in a very conservative manner. Conservative exposure parameters (e.g., intake rate, exposure frequency, and exposure duration) were used to calculate daily intakes. This may result in an overestimation of risk. In addition, there is significant uncertainty in the volatilization factor that predicts the concentration of VOCs in indoor air.

Risks from dermal exposures were calculated based on dermal toxicity values extrapolated from oral values using an absorption fraction of 1. Because organics are readily absorbed, the degree of uncertainty associated with this assumption is believed to be small. Thus, actual risks are likely to be slightly underestimated.

No EPA-approved cancer SFs for PCE are available on the EPA IRIS database. The oral and inhalation SFs used in this risk assessment are reported in EPA's draft document *Risk Assessment Issue Paper for: Carcinogenicity Information for Tetrachloroethylene*. Therefore, there is a high degree of uncertainty associated with the cancer toxicity of this compound, and the actual risks may be over- or underestimated.

In summary, estimates of exposure and risk are subject to a number of uncertainties that may lead to either an overestimate or an underestimate of risk. While the magnitude and direction of these uncertainties is largely unknown, it is most likely that risks estimated in this assessment have been overestimated as a result of the conservative assumptions contained in the various steps of the assessment. In either case the selected remedy would still be appropriate and protective and would not change.

7.2 ECOLOGICAL EVALUATION

An ecological risk assessment is a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. The EPA framework consists of a three-phased approach:

- Problem formulation
- Analysis
- Risk characterization

Problem formulation is a formal process for generating and evaluating preliminary hypotheses about why and how ecological effects may occur as a result of human activities. During problem formulation, available information is collected about the sources of stressors, stressor characteristics, exposure, the ecosystem potentially at risk, and ecological effects. Assessment endpoints can then be identified, and a conceptual site model developed. The conceptual site model describes the predicted relationships between ecological entities and the stressors to which they may be exposed. A complete exposure pathway from the stressor source to an ecological receptor must exist for the risk assessment to proceed.

A qualitative ecological risk assessment was performed for WS4 that consists of the conceptual site model portion of the problem formulation phase. The stressor present at the site (i.e., the wellfield) is PCE in the groundwater. WS4 is located in a primarily undeveloped area with open fields nearby where ecological receptors such as birds, small mammals, and invertebrates forage and live. However, these receptors are not exposed to contaminated groundwater, which occurs at a depth of about 50 feet below ground surface.

The aquifer that supplies raw water to WS4 (Troutdale Formation) is believed to discharge to the Columbia River approximately 3,500 feet downgradient from WS4. Although the Columbia River sustains major fisheries, it transports vast quantities of water, and infiltration of contaminated groundwater from WS4 would be unlikely to have a detectable effect on water quality in the Columbia River.

Because there are no potentially complete exposure pathways at WS4, there is no ecological risk.

8.0 REMEDIAL ACTION OBJECTIVES

8.1 NEED FOR REMEDIAL ACTION

Even though the risks presented in the baseline risk assessment are within the NCP acceptable risk range, it is necessary to take an action at WS4 because groundwater has been shown to have persistent concentrations of PCE above the MCL. EPA's 1991 guidance (*Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*) states that exceedances of the MCL can trigger the need for action. In addition, the NCP requires that MCLs must be met in groundwater, not just at the tap.

Although there are many uncertainties associated with this risk assessment, and PCE concentrations in groundwater at WS4 have been decreasing since mid-1993, concentrations during 1998 were still from 2 to 8 times the MCL.

Actual or threatened releases of hazardous substances from WS4, if not addressed by implementing the response action selected in this ROD, may present imminent and substantial danger to public health.

8.2 POTENTIAL SOURCES

Although numerous investigations have been conducted and 25 monitoring wells have been installed over the last 10 years, an ongoing source for which cleanup action could be taken has not been identified.

Dry cleaning facilities on the Mill Plain plateau, approximately 1 mile north/northeast of WS4, were identified early in the investigations as a probable source of the PCE at WS4. However, these investigations were largely completed by 1992, before the sudden increase in PCE concentration at WS4 and nearby PW-2. Although 17 monitoring wells have been installed in the vicinity of the dry cleaning facilities, PCE has been detected in these wells at only a fraction of the concentrations measured in WS4 wells. While it is therefore difficult to conclude that the dry cleaners are the primary source of PCE at WS4, it is probable that they contributed to the contamination. Elevated concentrations of PCE have been measured in both the shallow and deep groundwater zones in the plateau area. The capture zone of WS4, although not well defined, almost certainly includes deep groundwater from the plateau area.

The extent of the high-concentration PCE plume is not known, but the significant reduction in concentration in production wells, monitoring wells, and private wells over the last several years indicates that there is not an ongoing source of PCE contamination in the area.

Other potential primary sources of PCE at WS4 are speculative. The sharp increase and relatively fast decrease in PCE concentrations are consistent with a large, sudden release in the immediate vicinity of the wellfield, perhaps from illegal dumping. There is no direct evidence of this, however, and the identity of the source or sources primarily responsible for the observed PCE contamination at WS4 remain unknown. Because the PCE concentrations at WS4 have been steadily declining, and the treatment system at WS4 is effective and reliable, further investigation into source identification does not appear to be warranted. Given the extensive area in which the release could have occurred, and the improbability of identifying the source even with a larger investigation, the cost of additional investigation was determined to be disproportionate to the benefit. The concentration of PCE at the source or sources has almost certainly decreased significantly during the last 10 years and it is unlikely that an effective cleanup could be completed, given the high probability that PCE has moved via groundwater and sorbed onto soil over a large area. A fully effective cleanup of the source would not, in itself, immediately eliminate the need for continued treatment at WS4.

8.3 TRANSPORT OF PCE TO WATER STATION 4

A pulse of groundwater with high concentrations of PCE moved through the WS4 wellfield and immediate vicinity from about 1991 through 1993. The highest concentrations of PCE (approximately 500 to 1,600 µg/L) were measured at the production wells and a single, nearby private well (PW-2).

8.3.1 Mill Plain Release Scenario

If dry cleaners on the Mill Plain plateau were the primary source of PCE at WS4, it seems likely that hundreds of gallons of PCE (and perhaps much more) would have had to have been released in a relatively short time to account for the spike in concentrations that began in 1992. More than 200 gallons of PCE have been removed to date by the air stripping system at WS4, so the primary source of PCE would have had to have been at least several times that volume (or even more, if the release point was as far away as the Mill Plain plateau).

If such a large release had occurred in the Mill Plain area, it would have almost certainly caused a high-concentration plume of PCE in the shallow groundwater zone. Any PCE that was released at the surface on the plateau would have migrated through the soil column and dissolved into the shallow aquifer. A steady, long-term release would have gradually increased the concentration of PCE in the surrounding shallow groundwater. A sudden, large release could have resulted in free-phase PCE settling onto the aquitard at the bottom of the shallow groundwater zone. (This would only occur if the release of PCE was large and sudden enough to overcome the solubility limit in water, approximately 150,000 µg/L.) The resulting plume of PCE would have spread with groundwater flow (towards the west). Although such a plume could have been relatively narrow, it seems highly unlikely that it would be undetected by any of the shallow monitoring wells in the area.

8.3.2 Flowpaths to WS4

To reach WS4, the plume of PCE in shallow groundwater (or, if present, free-phase PCE) would next have had to move through the aquitard at the bottom of the shallow groundwater zone, through an unsaturated zone above the deep groundwater, and finally into the deep groundwater being drawn towards WS4. Even if most of the PCE moved through a large hole in the aquitard, a plume of PCE in the shallow groundwater should still be identifiable. But investigations to date have not indicated the existence of such a plume; concentrations of PCE measured in shallow groundwater at the Mill Plain plateau have exceeded 25 µg/L only three times.

The next highest concentrations of PCE in groundwater (approximately 50 to 150 µg/L) have been measured in several locations in the vicinity of WS4 (mostly in deep wells), but they do not form an apparent pattern or indicate a common plume of PCE contamination. It is possible that these areas are related, although the available data are not sufficient to establish relationship. It is more likely, however, that the PCE contamination in groundwater near WS4 is the result of multiple, independent releases or sources; PCE has been detected over too large an area to be accounted for by a single point release. It is also likely that one or more of those releases was relatively large and sudden, given the sudden increase and relatively fast decrease in PCE concentrations at WS4 production wells.

Of more than 30 production, monitoring, and private wells sampled in various investigations over the last 10 years, only monitoring well MW4-3, a deep well on the plateau, has not shown a significant trend of decreasing PCE concentrations since 1992. Concentrations at MW4-3 have remained relatively consistent at 10 to 20 µg/L.

8.3.3 Preferential Pathways

Controlled studies have shown that PCE can travel in narrow, preferential pathways, particularly through the unsaturated soil column. Although it is possible that such preferential pathways have transported PCE to WS4, it is not likely that a large volume of PCE could have moved through two groundwater formations and an intermediate aquitard without being detected by an array of shallow and deep monitoring wells between the presumed source (Mill Plain plateau) and WS4.

8.3.4 Degradation of PCE in Groundwater

PCE will eventually degrade into less complex molecules, leaving a chemical chain of breakdown products that includes TCE and DCA. The conditions that lead to chemical degradation can be complex, but degradation is generally thought to best occur under anaerobic conditions. A comprehensive study of PCE degradation was not conducted at WS4 because a primary, ongoing source was never identified and the treatment system is effective and reliable. However, primary degradation products of PCE (including DCA and TCE) were analyzed for in all monitoring well samples. Although these compounds were occasionally detected, they were not found in sufficient concentrations to indicate that chemical degradation of PCE was a significant factor in the trend of decreasing PCE concentrations in groundwater near WS4.

8.4 CONCLUSIONS

The PCE contamination at WS4 is persistent and present at levels that require continuing treatment to protect human health. (There are no complete pathways for ecological receptors and therefore there is no ecological risk.) There is no suspected ongoing PCE source for which cleanup action could be taken, and additional investigations into possible sources or channels would not be cost-effective. Such investigations would be cost prohibitive because the area to be covered is extensive. It is probable that even an exhaustive investigation would fail to provide significant additional information about potential sources. If a potential primary source were identified, it is probable that no direct action would be feasible. Even if further remedial action were feasible, it is likely that continuing operation of the treatment system at WS4 would be required. It is therefore appropriate to continue treating the water from WS4, both to remove PCE from the drinking water supply and to reduce the concentration of PCE in the groundwater.

8.5 REMEDIAL ACTION OBJECTIVES

The primary remedial action objective for WS4 is to

- Protect human health by reducing concentrations of PCE and other VOCs in drinking water produced from WS4 to below the MCL specified in regulations promulgated under the federal Safe Drinking Water Act (SDWA) and in the state drinking water regulations

An additional remedial action objective for WS4 is to

- Protect human health by reducing concentrations of PCE and other VOCs in groundwater at WS4 to below the Method A cleanup level specified in the Washington State Model Toxics Control Act (MTCA) regulations and below the federal and state drinking water standards (MCLs)

The federal MCL and the state groundwater cleanup level under MTCA Method A are both 5.0 µg/L for PCE. Currently, the only chemical of concern is PCE. If other chemicals of concern are found in future monitoring, the cleanup level for those chemicals shall be the MCL or MTCA.

9.0 DESCRIPTION OF ALTERNATIVES

At WS4 a treatment system consistent with EPA's presumptive remedy for VOCs in groundwater (OSWER Directive 9283.1-12, October 1996) has been constructed and is operating effectively. Removing the source of contamination is not feasible because no ongoing source of PCE for which cleanup action could be taken was identified. Accordingly, the feasibility study was limited to evaluation of the operating treatment system alternative and the no-action alternative. Evaluation of a no-action alternative is required under CERCLA to establish a baseline for comparison.

As discussed in Section 8, the two remedial action objectives for WS4 are to treat the water to achieve the MCL for PCE and other volatile compounds at the tap and in groundwater.

9.1 THE OPERATING TREATMENT SYSTEM ALTERNATIVE

The operating treatment is air stripping. Air stripping is a treatment technology in which the water to be treated trickles down through a tower in a "packed column" that breaks up the flow of water to create as much surface area as possible, as illustrated in the drawing of a typical packed tower configuration (Figure 9-1). Large volumes of air are then forced upward through the water, transferring the volatile contaminants from the surface of the water to the air through the process of evaporation. The air to which the contaminants have been transferred is in turn treated by being forced through carbon filters, which adsorb the contaminants. The filters are then regenerated or treated and disposed of as a hazardous waste. This alternative includes monitoring both the untreated and the treated water to ensure cleanup standards are met.

The air stripping system at WS4 consists of two packed towers operating in series. The system has been operating since January 1992. Use of air stripping has reduced concentrations of PCE (and other VOCs that may be present) in treated water to below the level of detection.

9.2 THE NO-ACTION ALTERNATIVE

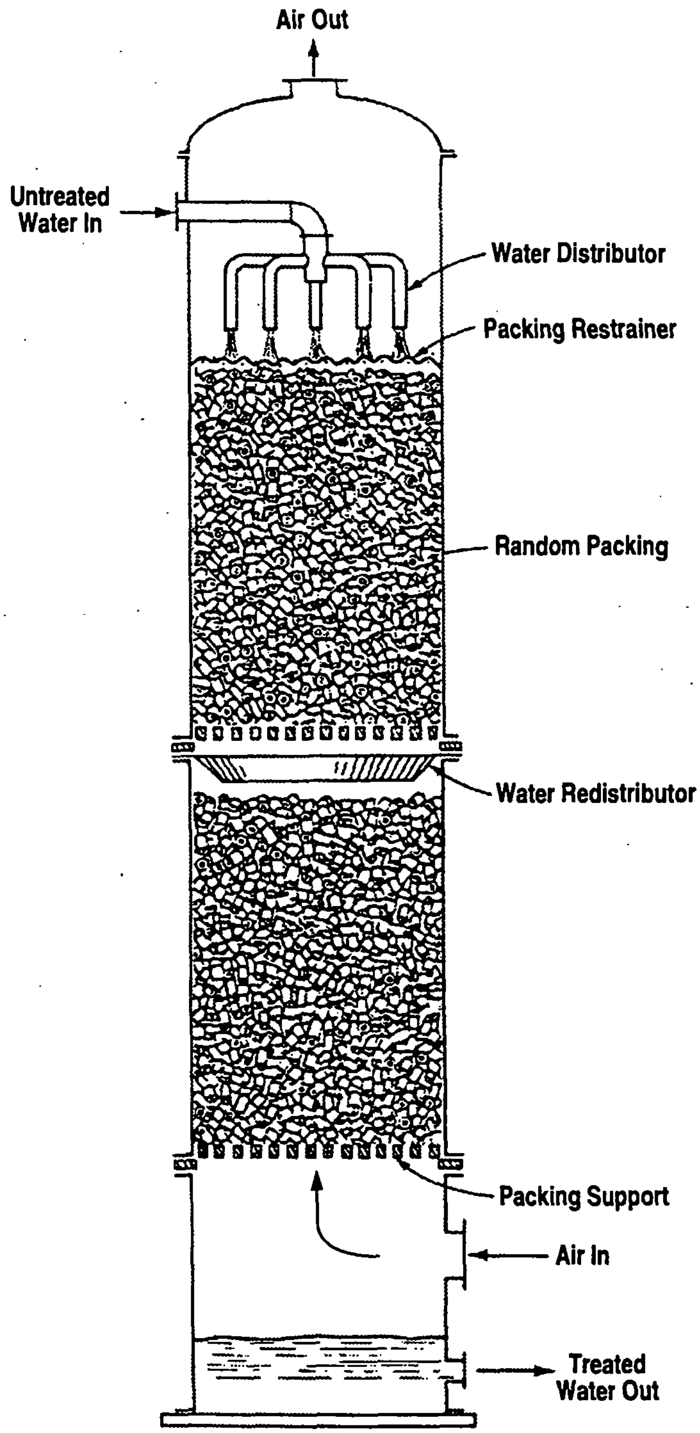
The aquifer under WS4 contains groundwater with PCE at concentrations greater than the MCL. Under the no-action alternative, there would be no treatment of water to remove PCE. Because all of the wells at WS4 have PCE concentrations that exceed the MCL, blending the untreated output from all of the WS4 wells would not reduce the PCE concentration to below the MCL. On-going monitoring of the water would continue under the no-action alternative.

It should be noted, however, that the City of Vancouver has no plans to discontinue treatment and would only do so if further investigations were conducted that demonstrate that no other VOCs are present in the groundwater and that PCE concentrations in groundwater have fallen to below the MCL.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

EPA has established nine criteria for the evaluation of remedial alternatives:

1. Overall protection of human health and the environment
2. Compliance with applicable or relevant and appropriate requirements (ARARs)
3. Long-term effectiveness and permanence



EPA REGION 10

Figure 9-1
Typical Air Stripper

54-52-OJ3C
Vancouver Water Station 4
RECORD OF DECISION

416252030-11-041499

4. Reduction of toxicity, mobility, and volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost of implementation
8. State acceptance
9. Community acceptance

The following sections summarize the detailed evaluation of alternatives in regard to these nine criteria. For the WS4 site, the evaluation of alternatives is limited to the operating treatment system alternative and the no-action alternative.

10.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The operating treatment, air stripping, has been proven to be effective in removing VOCs, including PCE, from water, based on operational data at this and other sites. It therefore meets the threshold criterion of protecting human health. (There is minimal risk to the environment from this site because there is no potentially complete and/or significant exposure pathway to untreated water for ecological receptors.) If compared against other removal technologies or measures, air stripping would be rated excellent for protecting human health.

The no-action alternative would not be protective of current human health because routine monitoring of untreated water has shown consistent concentrations of PCE above the MCL. Furthermore, because most of the samples taken from untreated water were analyzed only for PCE, it is possible that other VOCs are present in the groundwater. Exposure to other VOCs in the groundwater, together with exposure to PCE, could increase the risk. Given this uncertainty, the no-action alternative would not be adequately protective of human health. The no-action alternative would not be protective in the future because users of water drawn from WS4 would be exposed to unacceptably high concentrations of PCE.

10.2 COMPLIANCE WITH ARARS

This criterion states that remedial alternatives will meet all ARARs of other federal and state environmental and public health laws or provide justification for invoking a waiver.

The most significant ARARs for this site are the following:

- Federal and state Safe Drinking Water Act MCL for PCE of 5.0 µg/L

- Washington State Model Toxics Control Act (MTCA) Method A level for PCE of 5.0 µg/L; if other chemicals of concern are found in future monitoring, the cleanup level for those chemicals shall be determined by the ARARs listed in Section 12.2.1.

The operating air stripping system as installed is compliant with all ARARs. Moreover, if evaluated against other technologies or remedial measures, air stripping would be rated excellent for compliance with state and federal ARARs.

The City of Vancouver has designated the spent carbon to be dangerous waste, so treatment or disposal of spent carbon from the strippers must be compliant with Resource Conservation and Recovery Act (RCRA) Subtitle C and Washington State dangerous waste regulations.

The no-action alternative would not be compliant with ARARs because PCE concentrations in samples of untreated water consistently exceed the MCL. Under both the NCP and MTCA, the 5.0 µg/L concentration of PCE must be met both at the tap and throughout the groundwater.

10.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Remedial alternatives are typically assessed for long-term effectiveness and permanence and the degree of certainty that the alternative will prove successful in overall protection of human health and the environment.

The operating treatment system, with continued operation and maintenance, is effective in removing PCE (and other VOCs that may be present) from water. This treatment is permanent and achieves a high degree of certainty of success.

The no-action alternative would rate relatively low for long-term effectiveness and permanence because there would be no removal of contaminants from water.

10.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion assesses the degree to which the alternatives use active treatment to reduce toxicity, mobility, and volume of the principal threats posed to the site and local environment. The operating treatment system is very effective at removing VOCs from water, and therefore reduces the toxicity and volume through treatment. The treatment is irreversible and leaves no detectable concentrations of VOCs.

The no-action alternative would rely on natural degradation processes to reduce the toxicity, mobility, and volume of PCE. These degradation processes are complicated and have not been examined in sufficient detail at this site. Accordingly, the no-action alternative would rate very low for this criterion.

10.5 SHORT-TERM EFFECTIVENESS

The alternatives were evaluated in terms of their effectiveness in protecting human health and the environment during construction and implementation of the remedy and until the response objectives have been met.

The operating treatment system has already been installed, so there are no short-term effectiveness considerations for this site. Had the system been evaluated under this criterion before a decision was made, however, air stripping would have rated highly effective because the technology is well established and has proven to have relatively few short-term risks or potential environmental impacts. The proven nature of the technology also means that a construction schedule would have relatively few uncertainties.

The no-action alternative would probably rate average for short-term effectiveness. Although there are no impacts or risks for implementation of the no-action alternative, the time until protection is achieved would be very long.

10.6 IMPLEMENTABILITY

The technical and administrative feasibility of the alternatives was evaluated.

The operating treatment system has a well-established history as an effective means of treating water contaminated with VOCs. Air stripping systems are relatively simple to design and straightforward to maintain. Start-up and shut-down can be accomplished quickly, and the modular design makes an air stripping system easy to construct. Air stripping would rate high for implementability in any comparison with other alternatives for water treatment.

The no-action alternative would be easily implementable, so it would also rate high for this criterion.

10.7 COST OF IMPLEMENTATION

According to the City of Vancouver, the air stripping system at WS4 cost approximately $5 million to design and build (including approximately $2 million to build a pumping station and water line to operate the City's water system without WS4 until the treatment system at WS4 was complete.). Operating costs are estimated to be approximately $230,000 per year, not including depreciation. Air stripping systems typically rate well in comparison to other, equally effective treatment alternatives such as activated carbon or ultraviolet treatment of the water. Because how long the system will be needed is unknown, operating costs (and possibly replacement costs for a new system) could lead to a lower rating of air stripping for this criterion.

The no-action alternative would rate high for cost of implementation because there is no cost for the no-action alternative.

10.8 STATE ACCEPTANCE

This criterion was evaluated following the receipt of state agency and public comments on the RI/FS report and the Proposed Plan.

The Washington State Department of Ecology has reviewed the operating system alternative and supports the remedy.

10.9 COMMUNITY ACCEPTANCE

The community was given the opportunity to review the Proposed Plan and to request a public meeting if so desired. Written comments were received from two individuals and the City of Vancouver. All comments were supportive of the selected remedy. A detailed response to comments is provided in the Responsiveness Summary (Appendix A). There was no request for a public meeting and there were no objections to EPA's Proposed Plan.

11.0 THE SELECTED REMEDY

The selected remedy for cleanup of both groundwater and drinking water produced from WS4 is air stripping. This remedial approach is consistent with EPA's presumptive remedy for contaminated groundwater. It is protective of human health and the environment, provides the best overall effectiveness proportional to its costs, and includes treatment as a principal element. The selected remedy also includes monitoring to evaluate system effectiveness at removing PCE from both groundwater and drinking water produced from WS4.

11.1 AIR STRIPPING

Air stripping is a treatment technology in which the water to be treated trickles down through a tower in a "packed column" that breaks up the flow of water to create as much surface area as possible (Figure 9-1). Large volumes of air are then forced upward through the water, transferring the volatile contaminants from the surface of the water to the air through the process of evaporation.

The air to which the contaminants have been transferred is then treated by forcing it through carbon filters, which adsorb the contaminants. The filters are then regenerated or treated and disposed of as a hazardous waste.

The air stripping system at WS4 consists of two packed columns operating in series, and has been operating since January 1992. Use of air stripping has reduced concentrations of PCE in production water to below the level of detection.

The air stripping system is, and will continue to be, operated and paid for by the City of Vancouver. All drinking water produced by WS4 will be treated by the air stripping system until the City, the Washington State Department of Ecology, and EPA agree that the remedial action objectives have been met and the treatment can be terminated.

Groundwater will be pumped from WS4 at a rate that varies, depending on the time of year and customer demand. All water pumped by WS4 will be treated and distributed to customers as drinking water. Estimated costs for this remedy are:

Capital costs:	\$5,000,000 (construction completed in 1993)
Operation and maintenance costs:	\$230,000 per year (includes monitoring but not depreciation)

11.2 GROUNDWATER CLEANUP

By extracting and treating large volumes of groundwater for drinking water, WS4 acts as a very large pump-and-treat system for removing contaminants from the aquifer near WS4. The capture zone for WS4 is estimated to be approximately 5 square miles over a 30-year period of time; any contamination within this zone will eventually be pulled into the wellfield at WS4. Although the large capture zone has made it impractical to try to identify an ongoing source of PCE for which cleanup action could be taken, the high pumping rates for the production wells provide an effective means of reducing the concentration of PCE in the groundwater near WS4. Eventually, the extraction of groundwater will flush out residual contaminants in the wellfield, although the time to achieve the remedial action objectives is not known. Any decision to stop operating the treatment system must be made with the concurrence of EPA and the Washington State Department of Energy.

11.3 GROUNDWATER MONITORING

Periodic monitoring of the groundwater will be performed by both the City of Vancouver and EPA to evaluate the effectiveness of and the need for continued operation of the treatment system at WS4. Groundwater monitoring will consist of sampling production wells and monitoring wells for PCE and other VOCs. The City of Vancouver will continue to monitor the water at WS4 and will take at least one sample each year from each active production well. EPA will continue to review the City's data annually and will periodically, but no less often than every 5 years, sample the available monitoring wells near WS4.

The results of groundwater monitoring will be evaluated annually and at the 5-year review for WS4. Decisions on whether to continue and/or modify the monitoring program will be made by EPA in conjunction with the City of Vancouver and the Washington State Department of Ecology.

12.0 STATUTORY DETERMINATIONS

Under CERCLA Section 121, EPA must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), are cost-effective, and use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatments that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

12.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected remedy protects human health through treatment of drinking water produced from WS4 as well as groundwater by using air stripping to reduce PCE concentrations. The contamination of groundwater at WS4 with PCE does not pose a threat to the environment because the groundwater is 50 feet below ground surface.

Treatment of water produced from WS4 by air stripping reduces PCE concentrations to below detectable levels, and therefore there were no COPCs identified in treated water. There are no excess cancer or noncancer risks associated with ingestion, inhalation, or dermal contact with COCs in treated water because no such chemicals were identified.

Air emissions for the treatment system are in compliance with the permit issued by the Southwest Air Pollution Control Authority.

12.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND OTHER CRITERIA AND GUIDANCE

12.2.1 ARARs

The selected remedy, treatment of drinking water produced from WS4 by air stripping, complies with all applicable or relevant and appropriate requirements (ARARs) that have been identified. The chemical-, location-, and action-specific ARARs are presented below.

- **National Primary Drinking Water Regulations (40 CFR Parts 141.50 and 141.60) and Washington State Maximum Contaminant Levels (MCLs) (WAC Chapter 246-290-330).** These regulations, established under the Safe Drinking Water Act, are applicable to water at the tap. The federal MCL is relevant and appropriate to the groundwater of this drinking water aquifer.

- **Washington State Model Toxics Control Act Cleanup Regulations (WAC Chapter 173-340-720).** The groundwater cleanup levels established in the MTCA cleanup regulations are applicable to the groundwater at this site.

- **RCRA Regulations (40 CFR Part 261) and Washington Dangerous Waste Regulations (WAC Chapter 173-303).** The City of Vancouver has designated the spent activated carbon units from the air strippers as dangerous waste. The units are sent off site for regeneration or disposal as dangerous waste, and as such the requirements for manifesting and transport as dangerous waste and treatment or disposal at a permitted RCRA Subtitle C treatment, storage, or disposal facility are applicable.

- **U.S. Department of Transportation (49 CFR Parts 171 through 180) and Washington State Transportation of Hazardous Waste Materials (WAC Chapter 446-50).** If the spent activated carbon units contain hazardous waste, these transportation requirements would be applicable.

- **Washington Minimum Functional Standards for Solid Waste Handling (WAC Chapter 173-304); Washington Criteria for Municipal Solid Waste Landfill (WAC Chapter 173-351); County Health District regulations.** If carbon filters are NOT dangerous waste then they will be disposed of off site as solid waste under the applicable regulations.

- **General Regulations for Air Pollution Sources (Section 400), Southwest Air Pollution Control Authority.** On November 11, 1997, the City was granted Order of Authorization to Operate SWAPCA 95-CL-512 to operate the air pollution control equipment. Therefore, the requirements of the General Regulations and the Order of Authorization to Operate are applicable to the operation of the air strippers. Independent of CERCLA, the requirements of this permit (Order of Authorization to Operate) are the air pollution control requirements.

12.2.2 Other Criteria, Advisories, or Guidance to Be Considered (TBCs) for This Remedial Action

If the spent activated carbon used in treating the air stream at the air stripping system is disposed of or treated off site, the NCP off-site disposal rule (58 FR 49200, September 22, 1993) must be followed.

12.3 COST-EFFECTIVENESS

EPA believes this remedy eliminates the risks to human health. The system was designed and installed in 1992 at an estimated cost of $5 million. It has been operating successfully since then at an estimated cost of approximately $230,000 a year for operation and maintenance and monitoring (depreciation not included). Therefore the selected remedy provides an overall effectiveness proportionate to its costs, such that it represents a reasonable value for the money.

The selected remedy ensures a high degree of certainty that the remedy will be effective in the long term because of the significant reduction of the contamination in the water that has been achieved to date through use of the existing air stripping system. No other treatment options were evaluated because the existing system was already in operation when the site was listed on the NPL and the technology has proven to be effective for removal of VOCs from water. However, the cost for installing and operating an air stripping system compares well to other, equally effective treatment alternatives such as activated carbon or ultraviolet treatment.

12.4 USE OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT PRACTICABLE

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner for final source control at WS4. No ongoing source for the PCE in groundwater at WS4 has been identified within WS4, and numerous investigations have failed to determine an ongoing off-site source or sources of the PCE in the groundwater at WS4 for which cleanup action could be taken. Therefore a remedy that is focused on treatment of the drinking water produced from WS4 has been determined to represent the maximum extent to which permanent solutions and treatment technologies can be used in a cost-effective manner.

Because air stripping was already in operation when WS4 was listed on the NPL, it was the only remedy evaluated. However, treatment of the water using air stripping has been proven to be protective of human health, and it complies with ARARs. EPA and the State of Washington have determined that air stripping provides the best balance of trade-offs in terms of long-term effectiveness and permanence; reduction in toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost; while also considering the statutory preference for treatment as a principal element and considering state and community acceptance.

Air stripping, the selected remedy, treats the principal threat posed by exposure to drinking water produced from WS4 by reducing the concentration of PCE in treated water to below detectable levels. This remedy provides a proven technology for removal of PCE from water and is cost-effective. The selection of air stripping treatment of the contaminated water is consistent with program expectations that indicate that contamination in water used for public drinking water supply is a priority for treatment. The selection of air stripping treatment as EPA's remedy ensures long-term effectiveness by requiring that the treatment system remain in operation as long as necessary to reduce PCE concentrations in groundwater around WS4 to less than 5.0 µg/L.

12.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

Treatment by air stripping addresses the principal threat posed by drinking water produced from WS4 through the use of a proven treatment technology. By using treatment as the sole remedy, the statutory preference for remedies that employ treatment as a principal element is satisfied.

13.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan, released for public comment in May 1999, discussed remedial action alternatives for WS4 and identified air stripping as EPA's preferred alternative. No public meeting was scheduled. The public comment period was May 5, 1999, to June 3, 1999. Written comments on the Proposed Plan and RI/FS report were received from two individuals and the City of Vancouver.

EPA reviewed the written comments submitted during the comment period. Upon review of the comments, it was determined that no significant changes to the remedy for WS4, as it was originally identified in the Proposed Plan, were necessary to satisfy public concerns.

APPENDIX A

Responsiveness Summary

APPENDIX A
Responsiveness Summary

This responsiveness summary will address public comments on the Proposed Plan for remedial action at Water Station 4 (WS4) at Vancouver, Washington, upon completion of the public comment period.

The remedial investigation/feasibility study (RI/FS) report and Proposed Plan were released for public comment in May 1999. The two documents were made available to the public in the Administrative Record maintained at U.S. EPA Region 10, 1200 Sixth Avenue, Seattle, Washington, and at the information repository maintained at the Vancouver Public Library, Fort Vancouver Branch, 1007 E. Mill Plain Boulevard, Vancouver, Washington. The notice of availability of these two documents was published in the *Vancouver Columbian* on May 5, 1999.

Opportunity for Public Comment

The public comment period was held from May 5, 1999, to June 3, 1999. Written comments on the Proposed Plan were received from two individuals and the City of Vancouver during the comment period. Comments on the draft RI/FS report that were received from the City of Vancouver during the comment period for the Proposed Plan are also included in this Responsiveness Summary.

Opportunity for Public Meeting

The public had an opportunity to request a public meeting. No requests for a public meeting were received.

This responsiveness summary does not reproduce the original comments, but instead presents compilations of related comments that address the same concern. Original comments that relate to several different portions of the RI/FS report or the Proposed Plan have been combined and one response is given. Comments have been numbered to facilitate reference. The complete text of the written comments is available in the Administrative Record file.

Comments on the Draft Final RI/FS Report Received From the City of Vancouver During the Public Comment Period for the Proposed Plan

Comment 1: While it is true that no exclusive source of the PCE contamination at WS4 has been identified, and that EPA has not identified any specific sources that currently require source control remedial actions at the source location, it is not the case that no source has been *identified. PCE concentrations measured in groundwater samples collected immediately downgradient of Griffee's Cleaners and the Town Plaza strongly indicate that those dry cleaning operations are sources of PCE contamination. We suggest that all statements to the effect that no sources have been identified be rephrased to state that no sources have been identified that currently require source control remedial actions at the source location.*

Response 1: This commenter is correct that the term "source" as used in the RI/FS report and Proposed Plan needs clarification. As used in the RI/FS report and Proposed Plan, the term "source" was intended to describe a source that could be either (1) primarily responsible for the sustained high concentrations of PCE measured at WS4, or (2) subject to cleanup or other source control measures. The maximum PCE concentrations detected downgradient of Griffee's Cleaners and the Town Plaza were 1/10th of the average concentration of PCE measured at the wellfield in 1992 (and less than 1/20th of the concentration measured at PW-2, immediately upgradient of the wellfield.) Although the dry cleaners on the Mill Plain plateau may have contributed to the PCE contamination at WS4 to some extent (as stated in the RI/FS report), the data indicate that another source or sources were primarily responsible for the sustained high concentration of PCE measured at WS4.

To more precisely bound the definition of "source," that term in the Record of Decision (ROD) has been clarified by wording such as "no ongoing source of PCE contamination for which cleanup action could be taken."

Comment 2: EPA should clarify that although source control remedial actions may not be currently required at potential sources, those potential sources "may still be liable for remedial action costs" associated with the investigation and groundwater remediation.

Response 2: This commenter is correct that whether or not source control remedial actions are required for potential sources, those potential sources are not necessarily ruled out from potential liability for remedial action costs. Such liability issues are not addressed in these documents. The purpose of the RI/FS report is to assess the nature and extent of contamination and to analyze the range of cleanup alternatives for the site. The purpose of the Proposed Plan is to present EPA's proposed remedy for public comment. The purpose of the ROD is to document the final decision regarding the remedial action selected for the site and to explain why that remedy was selected. Issues of liability are not addressed in the RI/FS report, the Proposed Plan, or the ROD. These are technical documents that address matters related to the selection of the remedy.

Comment 3: Section 2.6 should state that the hydrogeologic unit in the WS4 area most likely consists of recent alluvium and Orchards Gravel, not the Troutdale Formation.

Similarly, in Section 4.2, the following wording is suggested for the seventh bullet on page 4-4: "WS4 wells pump from the alluvium in hydraulic communication with the deep zone."

Response 3: The commenter appears to be making the assumption that the Orchards Gravel extends from the Mill Plain plateau to the WS4 wellfield and therefore that there is a hydraulic connection between the shallow groundwater region at the Mill Plain plateau and the groundwater from which WS4 draws its water. The shallow aquifer beneath the Mill Plain plateau is known as the Orchards Gravel. The deeper groundwater zone is known as the Troutdale Formation. The alluvium is material near WS4 that could be hydraulically connected to either of these groundwater formations.

Based on a review of boring logs for the site, the Orchards Gravel does not extend to the base of the bluff where WS4 is located. The bluff itself likely represents an erosional surface where the Orchards Gravel was eroded by the Columbia River. The erosional surface somewhat increases geologic complexity and resultant subsurface uncertainty. However, it appears reasonably clear that the WS4 wells are screened either in the Troutdale Formation or in recently deposited alluvium in direct hydraulic communication with the Troutdale Formation.

Comment 4: Only March and September 1998 groundwater elevation data are presented. The text lacks discussion of seasonal variations in groundwater elevations, groundwater flow direction, and hydraulic gradient, which would affect fate and transport processes, particularly migration pathways from potential source areas to WS4.

Response 4: **Groundwater Elevations.** This commenter is correct that the RI/FS report does not include data showing seasonal variations in groundwater data. Seasonal variations in groundwater elevations, groundwater flow direction, and hydraulic gradient were not discussed for two reasons: (1) a full dataset for groundwater elevations was available only for March and September of 1998, and (2) those data did not indicate a significant difference that would affect the conclusions of the RI/FS report or the decision to continue operating the treatment system at WS4. A table showing the available seasonal groundwater surface elevations has been provided as an addendum to the final RI/FS report and is also attached to this responsiveness summary. Data from the entire study area are available only from two dry season dates (October 1992 and September 1998) and one wet season date (March 1998) because EPA had suspended the investigation. The time gap (almost 6 years) between October 1992 to September 1998 confounds comparison of these two data sets. The limited temporal data from the entire study area limits the evaluation of seasonal groundwater surface elevation fluctuations and therefore seasonal influences on contaminant fate and transport. However, the data do not indicate significant effects to fate and transport processes, including migration pathways.

Seasonal Fluctuations. Groundwater surface elevations in the shallow zone decreased in every measured well from March 1998 to September 1998. These decreases ranged from approximately 0.5 to 1 foot, with an average decrease of approximately 0.7 feet. This is an expected seasonal fluctuation from the wet season (March) to the dry season (September).

Groundwater surface elevations in the deep zone decreased in all but one of the wells from March 1998 to September 1998. The decreases ranged from approximately 0.25 to 4 feet, with an average decrease of approximately 2.9 feet. This is an expected seasonal fluctuation from the wet season (March) to the dry season (September).

Groundwater Flow Direction. The RI/FS report states that "groundwater flow in the deep zone is to the south-southwest across most of the study area." The two comprehensive data sets (March and September 1998) suggest that some seasonal fluctuation in the groundwater surface elevation occurs. However, the same general flow pattern was observed at both times. These limited observations indicate (1) that seasonal fluctuation of the groundwater surface elevations do not result in seasonal variation of contaminant fate and transport, and (2) that generally, PCE in deep zone groundwater will migrate to the south-southwest in the study area regardless of the season.

Comment 5: The apparent deep zone groundwater divide indicated in Figures A-3 and A-4 likely does not exist. MW4-PHC is deeper than other wells in the Troutdale Formation and the lower groundwater elevation at this well was used, in part, to create the figures, which resulted in the apparent divide. A more reasonable groundwater elevation map would indicate a southerly groundwater flow for the entire Mill Plain plateau.

Response 5: Given the limited deep zone data available in the area, the existence of a groundwater flow divide in the Parkhill Cemetery area cannot be conclusively confirmed or ruled out. The available data (without consideration of data collected from MW4-PHC) do suggest that groundwater flow in this area does have an easterly component. Inclusion of MW4-PHC suggests an even greater easterly component to flow. The gradient from MW4-3 to MW4-8I suggests an easterly component to flow. The gradient from MW4-2 to MW4-8I suggests a southeasterly component to flow. However, the gradient is much shallower in this area than from the Tower Mall to WS4. The shallow nature of the hydraulic gradient in this area introduces uncertainty that precludes drawing a high-confidence conclusion with respect to interpretation of groundwater flow.

Comment 6: The text does not discuss the hydraulic connection between the shallow and deep groundwater zones or compare horizontal flow to vertical flow in the shallow groundwater zone. Groundwater in the shallow zone flows to the west and also discharges vertically into the deep groundwater system. This connection is the primary pathway for contaminant migration from *potential sources on the surface in the Mill Plain plateau to WS4. The aquitard separating the two zones likely is a former weathered surface that was subsequently covered by the Orchards Gravel. The deposition of the younger gravel likely incised channels into and through the aquitard, which would have created vertical migration pathways. The detection of PCE in the deeper groundwater strongly indicates vertical contaminant migration through the aquitard.*

Accordingly, we suggest the following wording for the 10th bullet on page 4-4: "Pumping from WS4 wells captures groundwater over a large area from both the shallow and deep zones to the north."

Further, the statement that a large sudden release of PCE probably did not occur on the Mill Plain plateau is refuted by the indications of vertical flow discussed above. Vertical flow through the unsaturated zone, the thin shallow groundwater zone, and the aquitard, and/or a flushing event that released residual PCE in soil in the Mill Plain plateau are entirely plausible scenarios for the pulse detected in WS4.

Response 6: The competence of the aquitard and the presence of the unsaturated zone directly beneath the aquitard suggests that there is no significant direct hydraulic connection between the shallow zone (Orchards Gravel) and the deep zone (Troutdale Formation). That is, contaminant migration from the Orchards Gravel to the Troutdale Formation is likely to be limited to leakage from the Orchards Gravel through the aquitard. This leakage is probably dominated by percolation of groundwater through the aquitard at a rate controlled by the permeability of the aquitard material (orders of magnitude lower than the Orchards Gravel). In the absence of any direct evidence, the presence or absence of "incised channels," cracks, windows, or any other preferential vertical migration pathway in the aquitard can only be speculative. The existing evidence also cannot rule out a preferential vertical migration pathway through the aquitard.

Hydraulic communication between WS4 and the shallow zone (Orchards Gravel) is limited to the groundwater that percolates through the aquitard and reaches the saturated portion of the deep zone (Troutdale Formation) within the capture zone of WS4. The aquitard is competent enough to create the shallow saturated zone that is relatively areally extensive. This suggests that the effective average permeability of the aquitard is orders of magnitude lower than the Orchards Gravel. In addition, blow counts of the aquitard material range as high as 50 blows per 2 inches of penetration. This indicates that the aquitard material is very hard and not readily eroded.

In the Mill Plain area, the aquitard ranges from 4 to 8 feet in thickness, with the base of the aquitard at approximately 140 to 125 feet msl. Deep zone groundwater surface elevations average approximately 110 feet msl. These observations indicate that an unsaturated zone of soil that ranges from 15 to 30 feet in thickness is present beneath the aquitard.

Pumping from WS4 wells captures groundwater over a large area from the deep zone (Troutdale) and/or alluvium. However, the WS4 wells are screened at elevations between 150 to 200 feet below the base of the Orchards Gravel. The unsaturated zone between the bottom of the aquitard and the top of saturation in the Troutdale Formation precludes any sort of direct communication between the two formations or direct influence of WS4 pumping on the shallow zone. Given (1) the lack of direct hydraulic connection between the Orchards Gravel and the Troutdale Formation, (2) the differences in groundwater flow direction between these two units, and (3) the vertical separation between the intake screens and the bottom of the Orchard Gravel WS4 wells will capture groundwater from the Orchards Gravel only to the extent that it percolates through the aquitard to the underlying WS4 capture zone.

The detection of PCE in the Troutdale could suggest that PCE has migrated vertically through the aquitard and into the deep zone. However, detected PCE concentrations are generally lower in the shallow zone than in the deep zone (excluding WS4 sample results). Under these geologic and hydrogeologic conditions, and given available data, it is difficult to develop a scenario in which a PCE release from the Mill Plain area would result in concentrations in the deep zone that are greater than concentrations in the shallow zone. It is more likely that the PCE concentrations in the deep zone are a result of a release from an area outside of the Mill Plain area with contribution from the Mill Plain area via percolation through the aquitard.

Comment 7: The statement that degradation products of PCE include trichloroethane (TCA) and dichloroethane (DCA) is inaccurate. TCA is a primary chlorinated hydrocarbon compound used for industrial purposes, and DCA is a degradation product of TCA. The presence of TCA indicates a source of chlorinated hydrocarbons that may or may not be related to the potential sources of PCE.

The presence of TCA and DCA does not indicate degradation of PCE, which would occur under specific geochemical conditions that are not present in the area of WS4. PCE degradation likely is not occurring because of the lack of organic carbon required for microbial metabolism, and the presence of elevated dissolved oxygen concentrations, which limit PCE degradation.

Response 7: The RI/FS report did mistakenly include TCA as a degradation product of PCE; TCA is not a degradation product. However, there is evidence that dichloroethane (DCA) can be a breakdown product of PCE (although a minor one). As stated in the RI/FS report, there is very little evidence of degradation products of PCE in groundwater in the area of WS4. The lack of PCE degradation products could be either the result of specific geochemical conditions (as noted in the comment) or relatively low concentrations of PCE. Determining whether the very low level of DCA detected in groundwater was the result of PCE degradation or a release of DCA to the environment was beyond the scope of the investigation and would not have affected the selected remedy.

Comment 8: Groundwater results indicate the presence of PCE at WS4 both before and after the pulse of PCE in 1991. This indicates that the 1991 pulse was not the only release event that impacted the wellfield. PCE was likely released from multiple sources and multiple events. The distribution and migration pathways of PCE are unknown and no data exist that preclude another pulse of PCE entering WS4 in the future.

Response 8: The high concentrations of PCE measured at WS4 beginning in 1991 (the "pulse of PCE") may or may not be associated with the lower concentrations measured prior to that time. Data presented in the RI/FS report indicate that multiple sources of PCE probably contributed to the contamination at WS4. However, this conclusion is better supported by the high concentrations measured at PW-7, PW-8, and PW-9 than by the sudden increase at WS4 in 1991; it is likely that low concentrations of PCE would both precede and follow a higher-concentration pulse regardless of the initial source or sources.

We agree that no data exist that preclude another pulse of PCE entering WS4 in the future. It is inherently impossible to preclude that no future pulses of contamination will occur. Even if the past and current source or sources of PCE at WS4 were known, there is always the possibility of new future sources, particularly given the fact that surface stormwater runoff is routinely disposed of through dry wells in the area around WS4.

Comment 9: The pattern of decreasing concentrations applies only to the pulse of contamination. Continuous detections of PCE upgradient of WS4 indicate persistent contaminant migration, and a steady release of PCE to groundwater. Releases of PCE at the surface may have ceased, but residual PCE in soil may be slowly releasing PCE to groundwater, especially at MW4-3S, MW4-8S, and MW4-9S.

Response 9: The commentor is correct that residual PCE in soil may be slowly releasing PCE to groundwater; residual PCE in soil could be responsible for the PCE measured at both WS4 and monitoring wells in the vicinity. However, the data presented in the RI/FS report clearly show a pattern of decreasing concentrations of PCE in wells throughout the area of WS4 (of 29 monitoring and private wells, all but 3 showed decreasing concentrations of PCE from 1992 through 1998.) The continuing detections of PCE, both at WS4 and in wells throughout the area, clearly indicate that PCE remains in the environment. Whether these detections are the result of residual PCE in soil or in groundwater (or both) was beyond the scope of the investigation, and would not have changed either the conclusions or the selected remedy.

Comment 10: The distribution of PCE in the area north of WS4 indicates potential sources at Griffee's Cleaners and the Town Plaza. Although PCE concentrations may be lower than concentrations at or near the wellfield, this does not preclude them from being contributors of

PCE to the wellfield. As stated in the text, groundwater may flow in narrow channels, especially near sources where dispersion effects are small.

Response 10: Data presented in the RI/FS report indicate that dry cleaning operations at the Mill Plain plateau could have contributed to the PCE contamination at WS4. Although PCE plumes can flow in narrow channels, it is unlikely that a large (or steady, longer-term) surface release of PCE on the plateau could be the primary source of PCE contamination at WS4 (measured at hundreds of µg/L) without being detected at similar concentrations between the plateau and WS4.

Comment 11: The PCE concentrations in PW-7, PW-8, and PW-9 northwest of the wellfield are similar to those in the Mill Plain area, indicating that both areas contributed to the PCE at the wellfield.

Response 11: The concentrations of PCE measured at PW-7, PW-8, and PW-9 were higher than any concentration detected in the Mill Plain area. (The maximum measured concentration in these three private wells was almost three times the maximum concentration measured in any monitoring well in the Mill Plain area.) The groundwater flow patterns (both shallow and deep) in the area do not support a link between these two areas. It is reasonable to conclude that there probably are multiple sources of PCE in the area of WS4 as stated in the RI/FS report and the Proposed Plan.

Comment 12: Figure 4-1 suggests northerly groundwater flow in the shallow zone. All data indicate shallow groundwater flow is to the west.

Response 12: Figure 4-1 was not intended to show directional flow; it is a highly simplified illustration of the features affecting potential contaminant transport in the vicinity of WS4. As a two-dimensional representation of a three-dimensional condition, some simplification was necessary, and the groundwater flow direction arrow referred to in the comment was intended to represent flow out of the page. Directional headings are meaningless on this type of a simplified drawing. Calculated directional flows for both the shallow and deep groundwater zones are shown in Appendix A of the RI/FS report.

Comment 13: The soil-gas concentrations may be too low to indicate an exact location of a release of PCE, but do indicate at least a proximity to a source area, because PCE is a manmade chemical used for specific purposes and is not expected to occur widely in the environment. In addition, PCE is relatively volatile, and will not remain in the soil unless released in more than trace quantities. Soil-gas results should be considered as indicators of either a nearby source, or an old source that has substantially volatilized.

Response 13: As the comment notes, PCE is relatively volatile. Indeed, studies have shown that gas-phase PCE can travel relatively long distances through soil. Measurement of PCE in soil-gas may or may not indicate proximity to a source. Soil-gas data alone are insufficient to quantify the proximity, age, or size of the source.

City of Vancouver Comments on the Proposed Plan

Comment 14: The following statements in the Proposed Plan should be rephrased:

> *Introduction, page 1 ("no source of the PCE contamination has been positively identified for possible cleanup")*
>
> *Background, page 2 ("no source of the PCE contamination at WS4 was definitively identified")*
>
> *Results of Previous Investigations, page 3 ("neither the source nor the extent of the high-concentration PCE plume is known")*
>
> *Recommended Remedy, page 4 ("no PCE source has been identified")*

PCE concentrations in groundwater samples collected immediately downgradient of Griffee's Cleaners and the Town Plaza strongly implicate those dry cleaning operations as potential sources of PCE to groundwater. PCE concentrations at WS4 have not decreased to below detection limits, indicating that residual PCE sources remaining in soil continue to release PCE into groundwater. Potential PCE sources <u>have</u> been identified, but may not presently be amenable to direct cleanup.

We suggest that the following language be used on page 4 of the Proposed Plan: "No single PCE source of all contamination at WS4 has been identified. Multiple releases of PCE in the area of groundwater capture are likely responsible for PCE contamination at WS4. Recent groundwater test results suggest that source control/treatment is not called for, and that groundwater treatment at the water station is the preferred remedial action."

Response 14: The Proposed Plan for WS4 is final and its language will not be rephrased. The purpose of the Proposed Plan was to briefly summarize the information used to select the proposed remedy (continued air stripping at WS4), not to present a complete, detailed explanation of the more complex question of specific sources. The Proposed Plan stated that "Neither the source nor the extent of the high-concentration PCE plume is known." As noted in the responses to previous comments on the RI/FS report, this is a reasonable conclusion to draw from the available facts.

Comment 15: Page 2 of the Proposed Plan states that "Both the City and EPA continued these investigations." The City of Vancouver is currently continuing to pursue identification of possible sources of PCE.

Response 15: Comment noted.

Comment 16: Page 3 of the Proposed Plan states that "the significant reduction in PCE concentration over the last several years strongly supports the conclusion that there is not an ongoing source of PCE contamination in the area." However, PCE concentrations have not decreased to below detection limits at WS4, indicating the persistence of PCE sources in soil. Historical operations at dry cleaners typically did not manage wastes as rigorously as current industry practices. It is likely that multiple releases of PCE occurred in the groundwater capture area of WS4 in the past. These sources have the potential to continue to release PCE into groundwater that will migrate to WS4.

Response 16: As noted in both the RI/FS report and responses to previous comments, it is likely that residual PCE in soil will continue to release PCE into the groundwater that is eventually pumped from WS4. This residual PCE could be the result of one or more releases, as stated in the RI/FS report. Indeed, the high probability that PCE will continue to be present in the groundwater near WS4 was a major factor in EPA's decision to select continued air stripping as the remedy for this site.

Comment 17: Recent sampling results several thousand feet upgradient of WS4 indicate measurable PCE concentrations in groundwater. No data exist suggesting that another pulse of high-concentration PCE from an unidentified source will not move through the wellfield in the future.

Response 17: As stated in the RI/FS report, PCE has been routinely measured in groundwater throughout the area upgradient of WS4; 21 out of 29 monitoring and private wells sampled during the WS4 investigations had detections of PCE above the MCL.

EPA agrees that no data exist suggesting that another high-concentration pulse of PCE from an unidentified source will not move through the wellfield in the future. In fact, it is impossible to provide such data. The practice of disposing of surface stormwater runoff to dry wells in the vicinity of WS4 only complicates the question of whether concentrations of PCE will decrease, stay steady, or increase. In any case, the selected remedy will be sufficient to protect against any likely future increases in PCE concentrations at WS4.

Comment 18: Page 3 the Proposed Plan states that "this deep groundwater is the source of water pumped from WS4." However, we believe that WS4 captures both shallow and deeper *groundwater from a 5-square-mile area. Shallow groundwater within the capture area migrates vertically downward into the deep groundwater through a leaky aquitard.*

Response 18: As stated in previous responses to comments on the RI/FS report, there are no data supporting a direct connection between the shallow groundwater (from the Mill Plain plateau) and the groundwater from which WS4 draws. The shallow groundwater appears to be largely independent of the deeper groundwater zone. The extent of "leakage" through the aquitard has not been estimated, but the available data indicate that the aquitard is effective in preventing significant communication between the two groundwater zones.

Private Individuals' Comments on the Proposed Plan

Comment 19: I was offended when I found out my water was "not proper water." I contacted the city and a representative visited my home and instructed me now to treat the water from my taps so that it would be potable. I installed a water cleaning system and am now having no difficulties. I appreciate your efforts. I have recently been trying to use the water without my cleaning system and have found it acceptable. The result is that I believe that the means you are using to make the water acceptable are effective.

Response: It is unclear whether the water from this commenter's tap was from a private well or supplied by the City of Vancouver. Further, the nature of the difficulties with the commenter's tap water is unknown. If the commenter is using water from a private well, the air stripping system being used to treat City of Vancouver water from WS4 is not treating this water and the quality of the commenter's private well water, with or without use of an in-home cleaning system, is unknown.

If the commenter's water is being supplied by the City of Vancouver, it meets all EPA drinking water standards, and use of in-home water filtering would be based purely on personal preference for improved taste or odor but would not be required for health or safety reasons.

Comment 20: Thank you for the update. You appear to have done a thorough job in containing the risks from the pulse of PCE that entered the system. If the pulse has in fact passed, I would be interested in a discussion of the need to treat water compared to the value of monitoring, the cost of treatment compared to monitoring, and the possibility of using the savings [from monitoring instead of treating], if any, for other sites.

Response 20: Both monitoring and treatment need to be continued at WS4. PCE concentrations have dropped significantly; however, the concentrations of PCE in untreated water still exceed the maximum contaminant level (MCL) set by EPA for safe drinking water. Treatment will continue to ensure that PCE concentrations in the drinking water are reduced to levels that are below safe drinking water standards before the water is distributed to citizens for domestic uses. Monitoring will keep us informed as to the effectiveness of the treatment and will alert us if PCE concentrations rise to a level that would require increased treatment or other appropriate action.

Table A-1
Summary of Depth-to-Water Measurements and Groundwater Surface Elevations
Vancouver Water Station 4

Well ID	Top of Casing (ft msl)	Screen Interval (ft msl)	October 1992		March 1998		September 1998	
			Depth to Water[a] (ft btoc)	Groundwater Surface Elev.[a] (ft msl)	Depth to Water (ft btoc)	Groundwater Surface Elev. (ft msl)	Depth to Water (ft btoc)	Groundwater Surface Elev. (ft msl)
Shallow Wells								
MW4-3S	293.57	151 to 171	129.02	164.55	127.34	166.23	127.78	165.79
MW4-5S	285.46	153 to 163	NI	NI	NI	NI	121.47	163.99
MW4-8S	297.97	153 to 173	NI	NI	121.3	176.67	121.93	176.04
MW4-8I	297.41	120 to 125	NI	NI	NA	NA	121.47	175.94
MW4-9S	299.38	150 to 170	NI	NI	122.51	176.87	123.13	176.25
MW4-10S	294.11	144 to 164	NI	NI	115.84	178.27	116.55	177.56
MW4-11S	302.59	151 to 171	NI	NI	123.85	178.74	124.75	177.84
MW4-12S	293	148 to 168	NI	NI	NI	NI	126.64	166.36
MW4-13S	292.64	153 to 173	NI	NI	NI	NI	125.65	166.99
MW4-14S	291.74	153 to 163	NI	NI	NI	NI	126.42	165.32
Deep Wells								
MW4-1	132.66	13 to -17	126.84	5.82	120.51	12.15	124.98	7.68
MW4-2	291.56	92 to 112	175.55	116.01	172.98	118.58	173.22	118.34
MW4-3	293.68	89 to 109	178.53	115.15	175.75	117.93	176.05	117.63
MW4-4	30.56	-44 to -64	27.42	3.14		Well Abandoned		
MW4-5	283.51	84 to 104	167.01	116.5	164.46	119.05	164.3	119.21
MW4-6	139.04	-41 to -61	134.36	4.68	129.17	9.87	133.23	5.81

Table A-1 (Continued)
Summary of Depth-to-Water Measurements and Groundwater Surface Elevations
Vancouver Water Station 4

Well ID	Top of Casing (ft msl)	Screen Interval (ft msl)	October 1992 Depth to Water[a] (ft btoc)	October 1992 Groundwater Surface Elev.[a] (ft msl)	March 1998 Depth to Water (ft btoc)	March 1998 Groundwater Surface Elev. (ft msl)	September 1998 Depth to Water (ft btoc)	September 1998 Groundwater Surface Elev. (ft msl)
MW4-7	156.55	-23 to -43	148.57	7.98	142.36	14.19	146.36	10.19
MW4-8D	297.25	91 to 101	NI	NI	194.68	102.57	198.45	98.8
MW4-DP1	284.38	45 to 65	205.55	78.83	181.18	103.2	182.17	102.21
MW4-DP2	284.34	5 to -5	174.33	110.01	NA	NA	>201	NA
MW4-FS1	38.97	7 to -8	NI	NI	29.82	9.15	33.94	5.03
MW4-FS2	38.75	-42 to -52	NI	NI	NI	NI	33.68	5.07
MW4-HS1	138.95	1 to -9	134.75	4.2	129.71	9.24	133.88	5.07
MW4-PHC	292.12	62 to 72	198.12	94	193.94	98.18	199.46	92.66

[a]Source: R.F. Weston 1993

Notes:
ft btoc - feet below top of casing
ft msl - feet above mean sea level
NA - not available
NI - well not installed on specified measurement date